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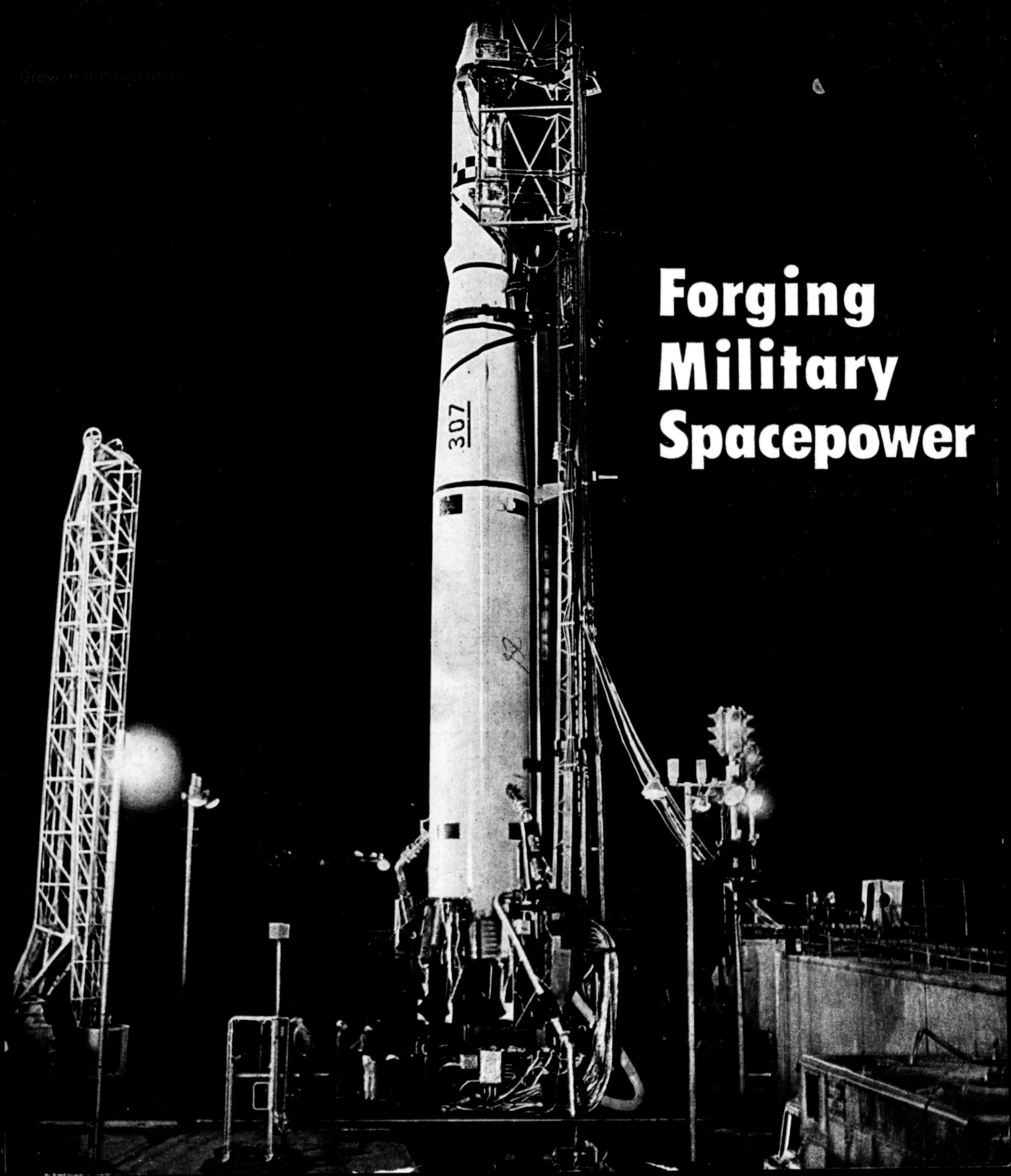
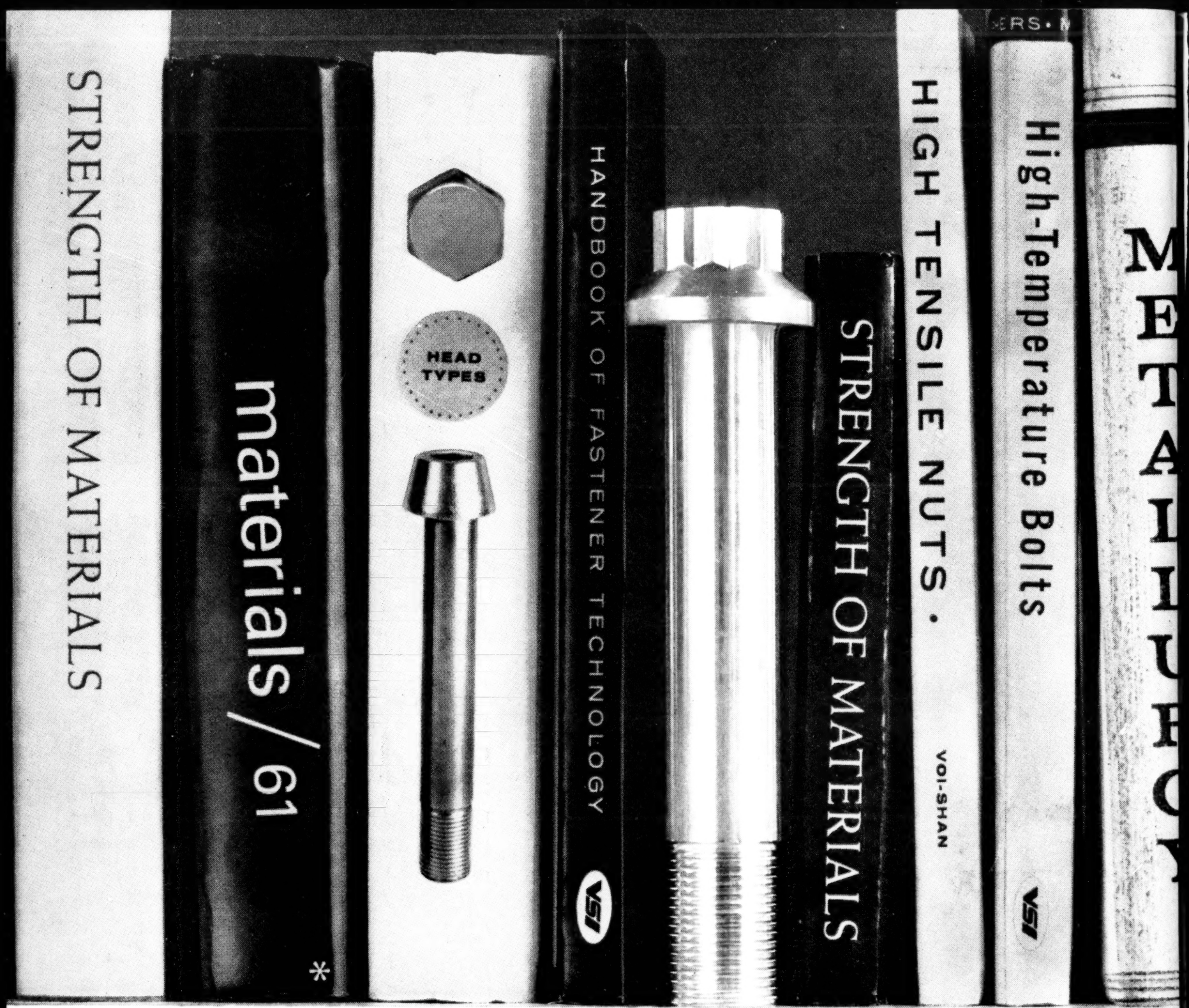
USAF SYSTEMS COMMAND ISSUE

McGraw-Hill Publications



Forging Military Spacepower



Volumes of Performance from Voi-Shan

Voi-Shan is noted for its ability to manufacture high-performance bolts, nuts and other precision fastening devices for the aircraft/missile industry. It is the nation's pioneer in Titanium bolt manufacturing and has worked with such exotic materials as Beryllium, Zirconium, and Columbium. Other exotic materials such as Tantalum and Tungsten are constantly being experimented with for their potential use as high-performance fasteners.

The table shown, is representative of Voi-Shan's range of experience in the manufacture of high-strength and high-temperature bolts. Write for descriptive literature on these and other Voi-Shan quality products.

Material	Room Temperature Minimum Ultimate Tensile Strengths (Typical)	Typical Temperature Usage Range	Typical Head Configurations
Mo +1/2% Ti	116,000 psi	—425 to 2500°F	100° Flat Head, Internal or External Hex or External 12 point Wrenching
Alloy Steel	160,000 psi	—100 to 550°F	
A-286 Corrosion Resistant Steel	160,000 psi	—425 to 1200°F	
Inconel X	165,000 psi	—425 to 1400°F	
M-252	170,000 psi	—425 to 1400°F	Threads: MIL-S-7742 (Class 3A)
Alloy Steel	180,000 psi	—100 to 550°F	
René 41	180,000 psi	—425 to 1600°F	100° Flat Head, Internal or External Hex or External 12 point Wrenching
K-Monel	180,000 psi	—425 to 1000°F	
Waspaloy	180,000 psi	—425 to 1400°F	
Udimet 500	195,000 psi	—425 to 1600°F	
A-286 Corrosion Resistant Steel	200,000 psi	—425 to 1200°F	Threads: MIL-S-7742 MIL-S-8879 (Class 3A)
PH 15-7 Mo	220,000 psi	—300 to 1000°F	
Hy-Tuf	220,000 psi	—100 to 550°F	Internal or External Hex or External 12 point Wrenching
Various	220,000 psi	—100 to 900°F	
5% Chrome	260,000 psi	—100 to 900°F	Threads: MIL-S-8879
Die Steels	280,000 psi	—100 to 900°F	(Class 3A)

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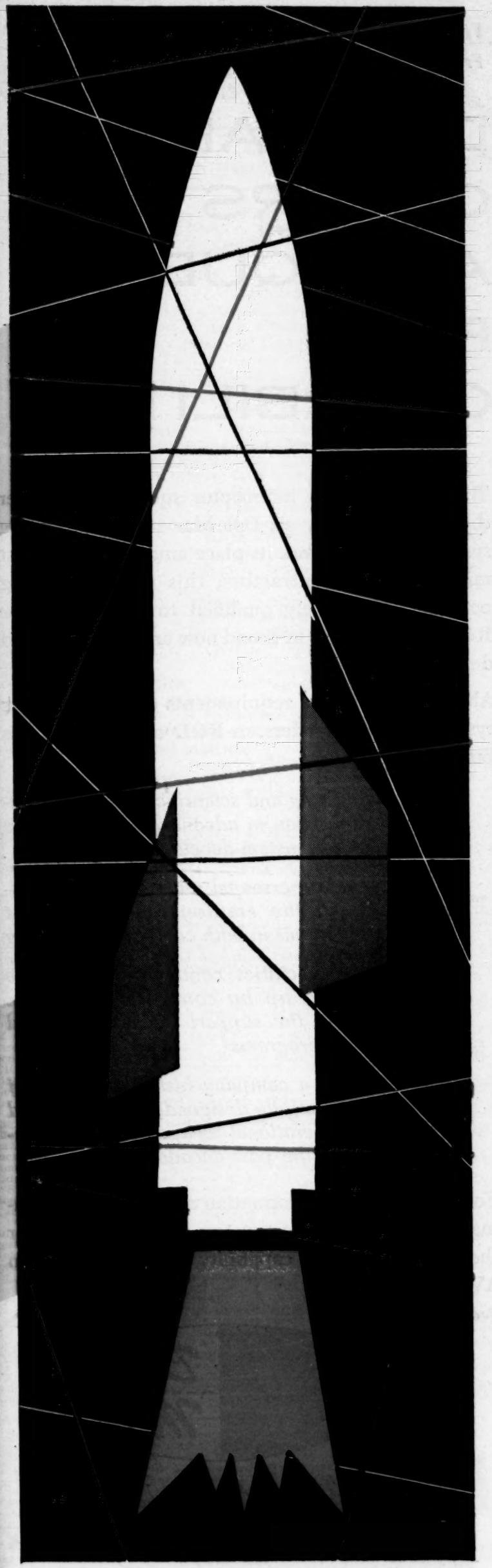

TEFLON® 100 FEP

now covered in MIL-W-16878D for military electronic hook-up wire

To electronic designers in the missile area, new opportunities are now open for improved wiring reliability. The recently issued "D" revision of Bureau of Ships' MIL-W-16878 specification for missile hook-up wire covers Du Pont TEFLON 100 FEP resin as insulation for continuous service up to 200°C.

Three constructions are included in the new spec:

Type KT—250 v. service (6-mil insulation)
Type K—600 v. service (10-mil insulation)
Type KK—1,000 v. service (15-mil insulation)

In all three types of constructions, the designer can obtain TEFLON FEP over either tin-plated or silver-plated conductors —in unlimited lengths.

In many constructions, the excellent dielectric properties of TEFLON FEP resin . . . its thermal stability . . . its low-temperature toughness . . . and its inertness to all chemicals and solvents will provide significantly increased reliability.

With this recent inclusion, FEP joins the older members of the family of TEFLON fluorocarbon resins—the TFE resins—as approved insulations meeting MIL-W-16878. Only TFE and FEP resins are permitted for thin-wall constructions under this spec.

Another military application utilizing TEFLON FEP resin is covered in MIL-C-17C—jacketing material for coaxial cable.

For more information about the properties and advantages of hook-up wire insulated with FEP resin, write to E. I. du Pont de Nemours & Co. (Inc.), Dept.AV-10,Room 2526T, Nemours Bldg., Wilmington 98, Delaware.

In Canada: Du Pont of Canada Limited, P. O. Box 660, Montreal, Quebec.

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FLUOROCARBON RESINS

TEFLON is Du Pont's registered trademark for its family of fluorocarbon resins including TFE (tetrafluoroethylene) resins and FEP (fluorinated ethylene propylene) resins.

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(3) Laboratory facilities conducive to creative work backed up by complete production facilities for the support of developmental and testing programs

(4) And, finally, a company historical record of having successfully designed, developed, and produced operational weapons training systems during the past decade.

For more complete information on this unique training and weapons support system capability, write for the Del Mar R&D capability brochure, Bulletin AW-933-4.

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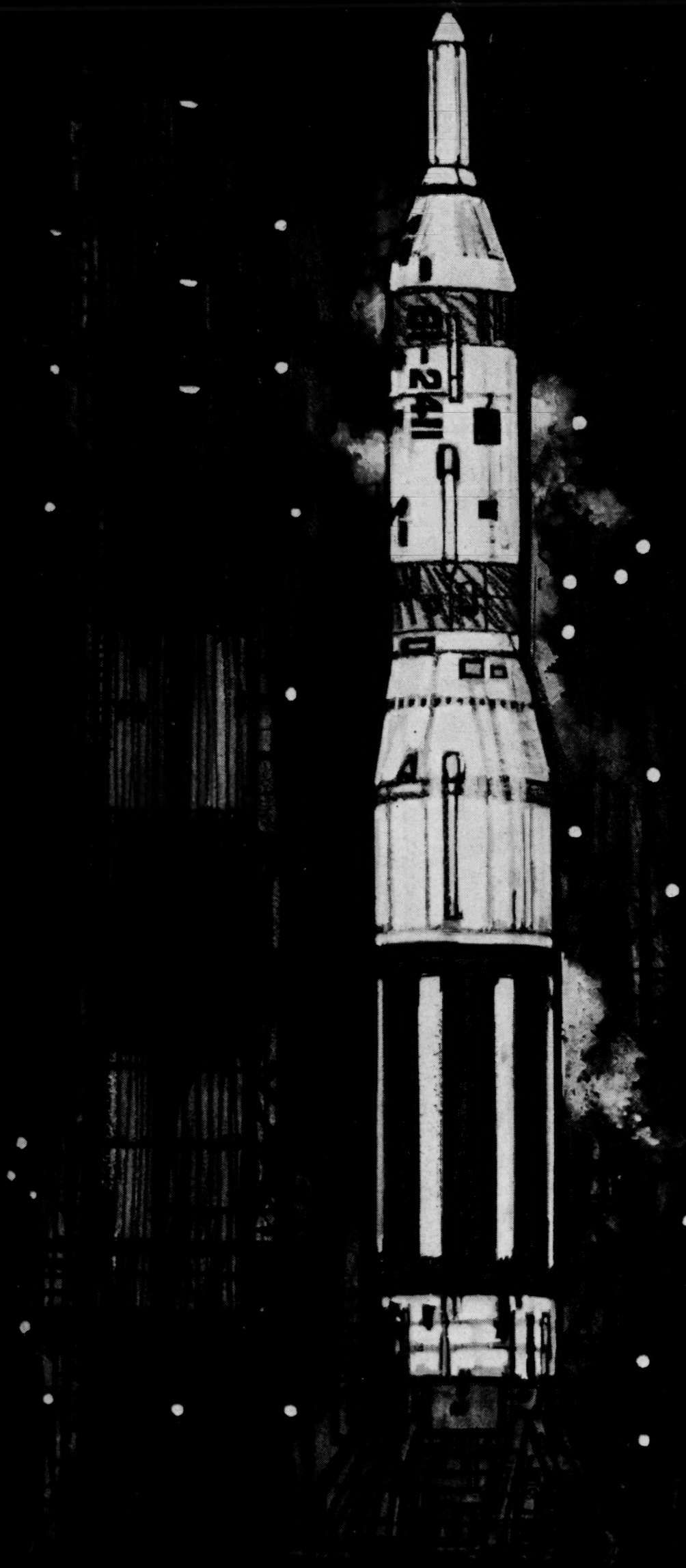

TAMING THE WILD BLUE YONDER

Primary responsibility for research, development, production, testing and evaluation of the Air Force's newest weapons systems—this is the mission of the recently created Air Force Systems Command. To its men—our defense architects—this mission presents the eternal challenge . . . that of taming the wild blue yonder.

AFSC

In pursuit of this challenge AFSC must call upon the vast resources of industry and of education, as well as those of the military. AC Spark Plug is being called upon to develop and produce the small, yet highly accurate inertial guidance system for the TITAN II. This is but one example of American industry and government working together so peoples of the world may live together—in peace.

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AChiever inertial guidance systems for Titan II, Thor and Mace. Bombing navigation systems for the B-52 and B-47.

If you are an experienced radar systems engineer interested in working on the B-52 Bombing Navigational System Integration Program, please contact Mr. G. F. Raasch, Director of Scientific and Professional Employment, 7929 South Howell, Milwaukee 1, Wisconsin. All qualified applicants will receive consideration for employment without regard to race, color, creed or national origin.

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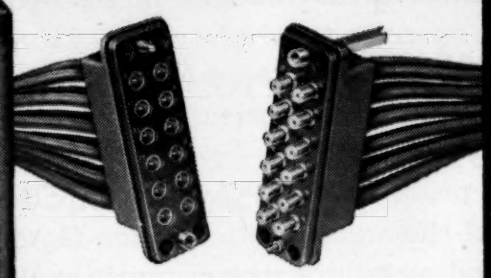
reliable solderless contacts result in dramatic reduction of installation time

wide application—all with snap-locked removable contacts



Type MB-X

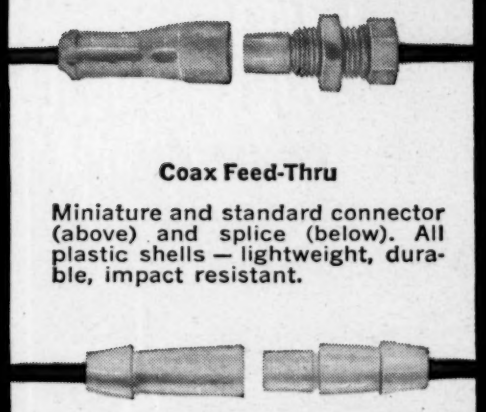
Coax in miniature rectangular configurations.

AQUALOK T.M.

Weather-sealed round connector—either all coax or in combination with single conductors.

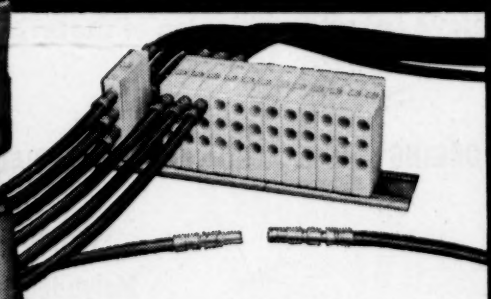
Coax Bantam HYFEN

Connectors for standard and miniature coax—either all coax or in combination with single conductors.



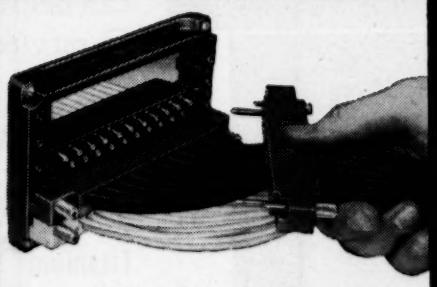
Coax Feed-Thru

Miniature and standard connector (above) and splice (below). All plastic shells — lightweight, durable, impact resistant.



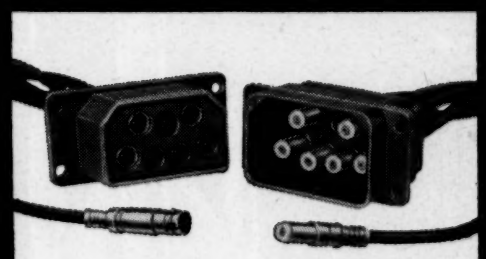
Coax MODULOK®

Modular terminal block with spring-loaded removable contacts.



Type PD-X

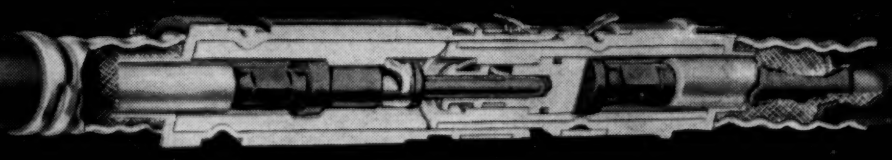
Modular HYFEN inserts for all standard or miniature coax or in combination with inserts for single conductors.



Type ME-X

Rack and panel HYFEN series—features one piece shell, one piece inserts.

Burndy's coax contacts, for both miniature and standard coax cable—feature crimped inner and outer contacts, which provide a more reliable connection, faster and easier. High speed production tooling results in low installed cost—crimps contacts in any circumferential position. Few parts simplify installation. No heat to damage insulation.



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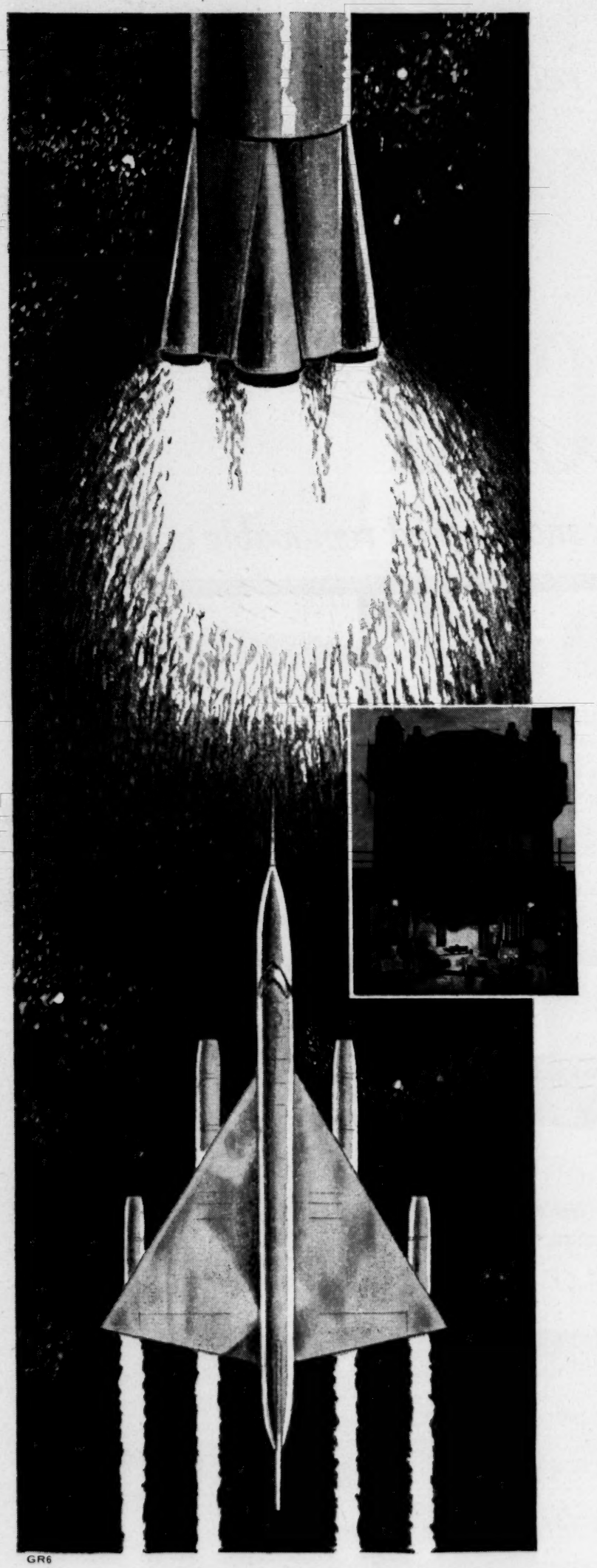

GR6

Forging a metal spectrum for any flight environment

Whether design criteria be Mach 2 or escape velocity — the part a wing spar or rocket motor nozzle — most of the significant advances in forging conventional, exotic and refractory materials come from Wyman-Gordon. Here, technical breakthroughs in size, complexity and strength-to-weight ratios of forged airframe hardware and propulsion components have materially raised performance ceilings for every type of vehicle — global bomber to deep space probe capsule. Always impatient with state-of-the-art concepts, Wyman-Gordon engineers and metallurgists constantly explore ways to bring hitherto "unforgeable" metals and alloys into operational use — broadening the spectrum of ultimate-performance materials available for advanced vehicle designs. Consultation on your project requirements can help achieve better correlation of materials to service environment.

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Hafnium	Tungsten
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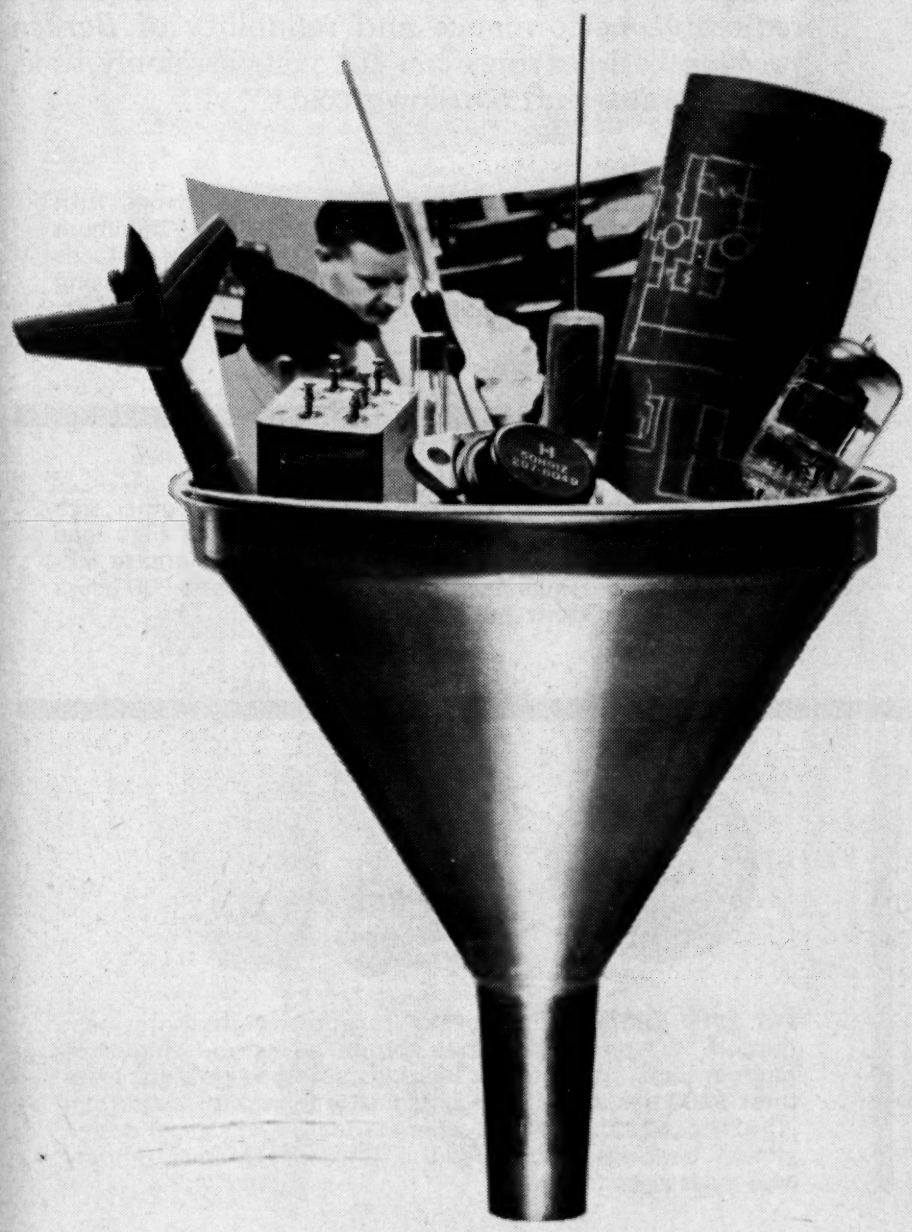

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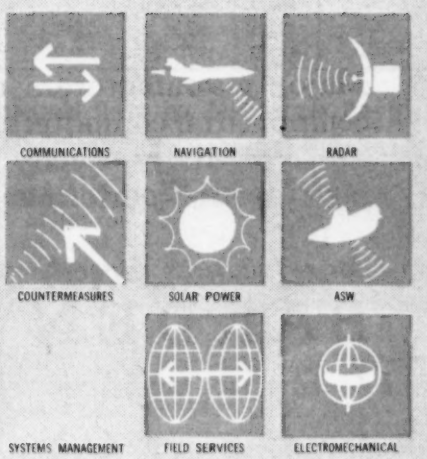

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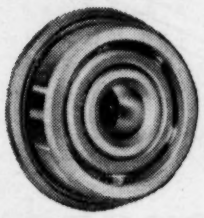
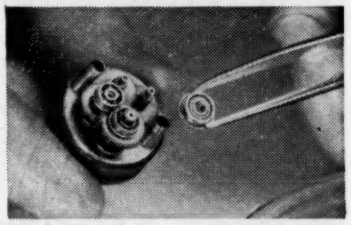
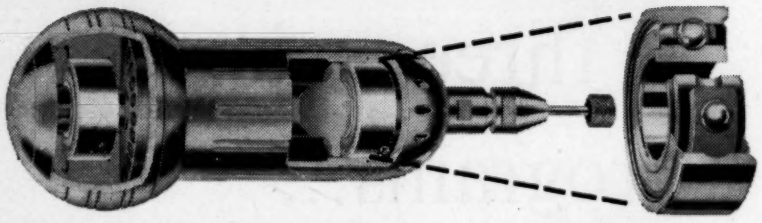
For less difficult applications, the consistent quality, predictable performance and reliability of *Barden Precision* ball bearings can cut your assembly time, rejection rates and teardown costs.

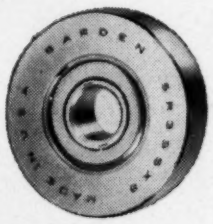




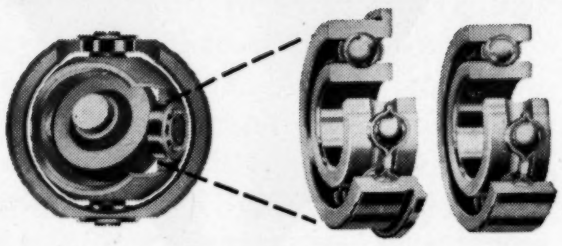
For gear trains: Barden standard low torque bearings with closely controlled radial play and low eccentricity assure minimum backlash. Precision flanges provide accurate positioning surfaces and permit through-boring, eliminating the need for housing shoulders and reducing manufacturing and assembly costs. Sizes from .1562″ to .8750″ O.D.



For power tools, aircraft and missile accessories, and other high speed applications: Barden "T" retainer bearings with high load capacity and long, trouble-free life. Double shielded, grease lubricated "T" retainer bearings have operated more than 6,000 hours at 80,000 RPM. Sizes from .5000″ to 3.3465″ O.D.

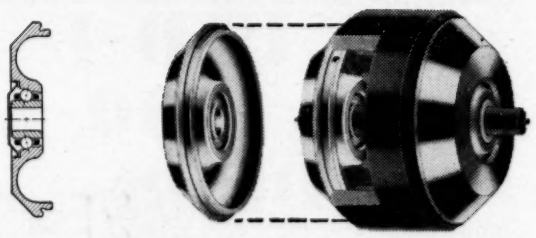


For synchros: Volume produced precision bearings with extra-large outer rings designed to serve as end caps, thereby reducing synchro complexity and cost and increasing air gap accuracy. Barden-developed synchro bearings have closely controlled radial play and minimum eccentricity to meet tight air gap specifications. Sizes from .3750″ to 2.0000″ O.D.

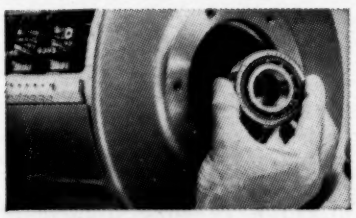


For gyro gimbals and other torque-sensitive devices: Barden "W" retainer reduces torque peaks and eliminates retainer lock. "W" retainer bearings save one gyro manufacturer $100 per unit by reducing costly teardown. Sizes from .1562″ to .6250″ O.D. Also other standard and special design gimbal bearings, including the Barden Dynamic Bearing with near-zero torque.

For gyro rotors: Barden special design end-bell bearings to increase accuracy and reduce assembly cost of miniature gyros. Bearings become part of spin mass and serve as end caps for wheel assembly, reducing mating part errors and improving squareness, concentricity and overall accuracy. Sizes from .615″ to 1.016″ O.D. Also other standard and special types including inertial gyro bearings with 20-microinch tolerances.



For memory drums, high precision spindles and other low runout applications: Barden duplex pairs with extremely low eccentricity and non-repetitive runout. Matched pairs with accurately controlled preload provide high load capacity, smoothness and long life along with radial and axial rigidity. Sizes from .3125″ to 3.3465″ O.D., deep groove or angular contact.



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To specify *Barden Precision* ball bearings—prototype, pilot run or large volume production—ask for a Barden sales engineer to give you on-the-spot assistance, or write for Catalog C-3.

for reliability...specify

BARDEN PRECISION BALL BEARINGS

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RCA PRESENTS A NEW MICROWAVE FAMILY

Integral-Cavity Pencil Tubes Shown Actual Size, Approximately

RCA Pencil Tubes provide the vital voice-communications link in the Satellite Communications System of Project Mercury

Integral-Cavity

PENCIL-TUBE OSCILLATORS

- From 900-3400 Mc
- Low-cost
- Includes RF Circuitry
- Compact

OVERALL RF PERFORMANCE ASSURED

Now, RCA offers the recognized performance-advantages of the famous coaxial pencil tube . . . in a design which combines the pencil tube with a mechanically-tuned cavity—to produce a single-unit, compact, low-cost microwave oscillator.

Wherever circuit compactness and gross weight are major considerations in microwave designs, RCA Integral-Cavity Pencil Tubes hold intrinsic possibilities—for CW, plate-pulse, or cathode-pulse work. There's a choice of over 20 types. And note this: RCA's Applications Engineering group is available to discuss special Integral-Cavity Pencil Tubes "tailored" to your specific requirements.

For information on RCA Integral-Cavity Pencil Tubes—and other integral cavity developments such as amplifiers, harmonic generators, voltage-tuned oscillators, get in touch with your RCA Field Representative. Or write: Microwave Marketing, Building 55, RCA Electron Tube Division, Harrison, N.J.

TYPICAL PERFORMANCE OF REPRESENTATIVE OSCILLATORS

RCA-Dev. Type	Power Output (Watts)	Duty Cycle	Freq. (Mc)	Input Pulse Voltage
A-15132	500 (Peak)	0.001	1100	50
A-15228	300 (Peak)	0.001	2000	50
A-15234	100 (Peak)	0.001	3000	50
A-15221	1	CW	1100	—
A-15227	0.3	CW	2000	—
A-15233	0.1	CW	3000	—

Important Technical Data for Microwave Designs

- RCA MICROWAVE TUBES and SOLID-STATE OSCILLATORS and AMPLIFIERS (ICE-180C). 16 pages of characteristics on nearly 100 RCA Microwave Devices. Please request on company letterhead.
- RCA PENCIL TUBES (ICE-219). 28-page book on Pencil Tube theory, application, characteristics curves, operating data. Price 50 cents. Please remit with order.

Send your order to—Section I-112-Q Commercial Engineering, RCA Electron Tube Division, Harrison, N. J.

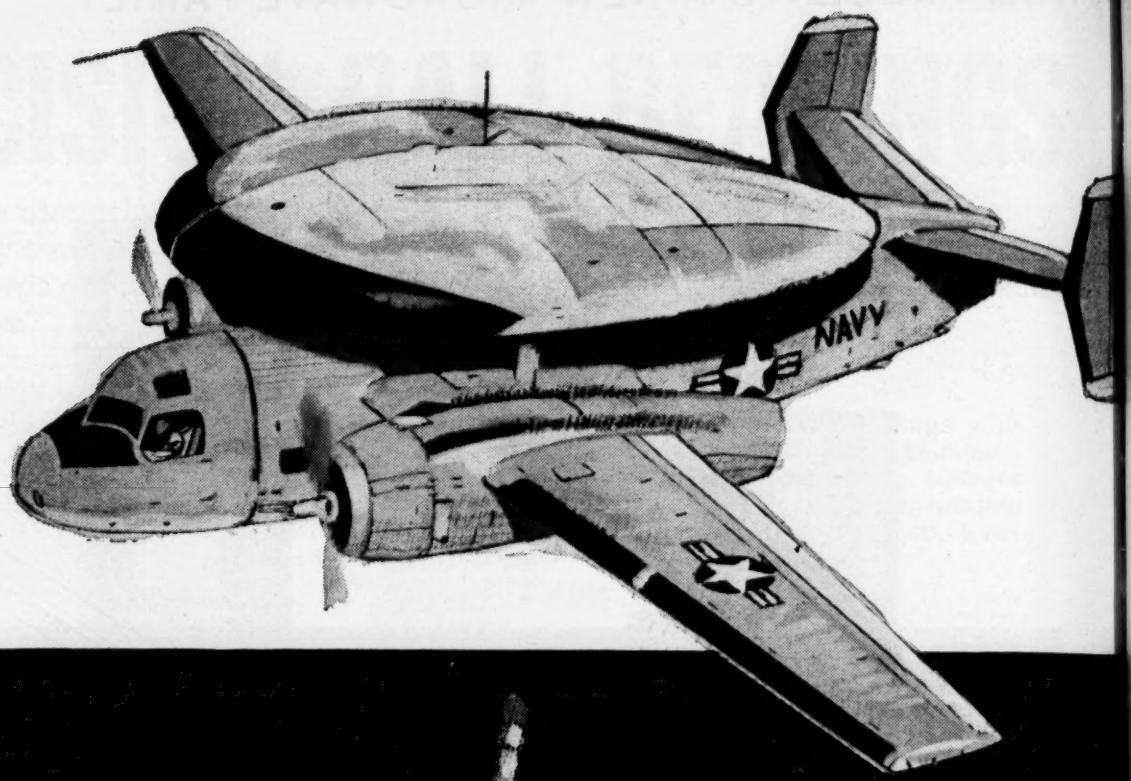
The Most Trusted Name in Electronics
RADIO CORPORATION OF AMERICA

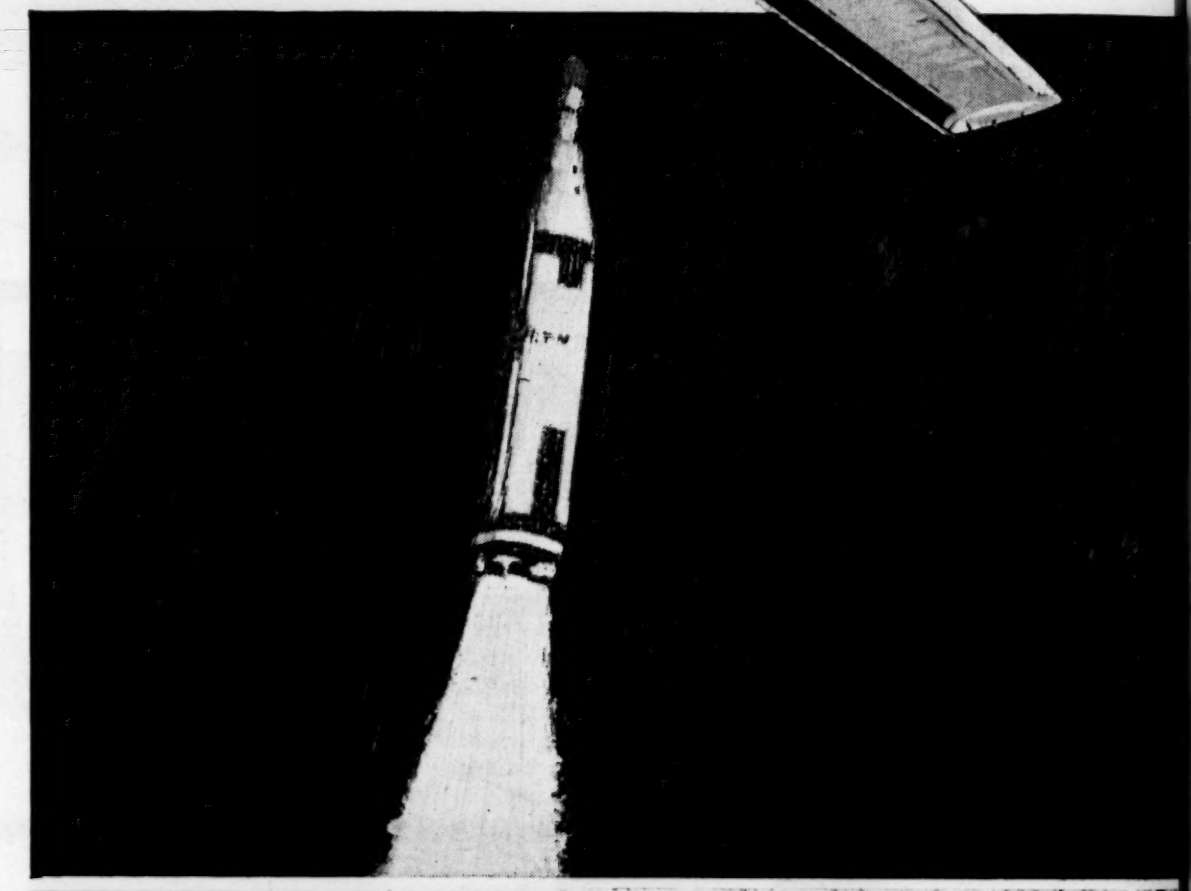
RCA ELECTRON TUBE DIVISION FIELD OFFICES... Industrial Product Sales: NEWARK 2, N. J., 744 Broad St., HU 5-3900 • CHICAGO 54, ILL., Suite 1154, Merchandise Mart Plaza, WH 4-2900 • LOS ANGELES 22, CALIF., 6801 E. Washington Blvd., RA 3-8361 • BURLINGAME, CALIF., 1838 El Camino Real, OX 7-1620 • **Government Sales:** HARRISON, N. J. 415 South Fifth St., HU 5-3900 • DAYTON 2, OHIO, 224 N. Wilkinson St., BA 6-2366 • WASHINGTON 7, D.C., 1725 "K" St., N.W., FE 7-8500

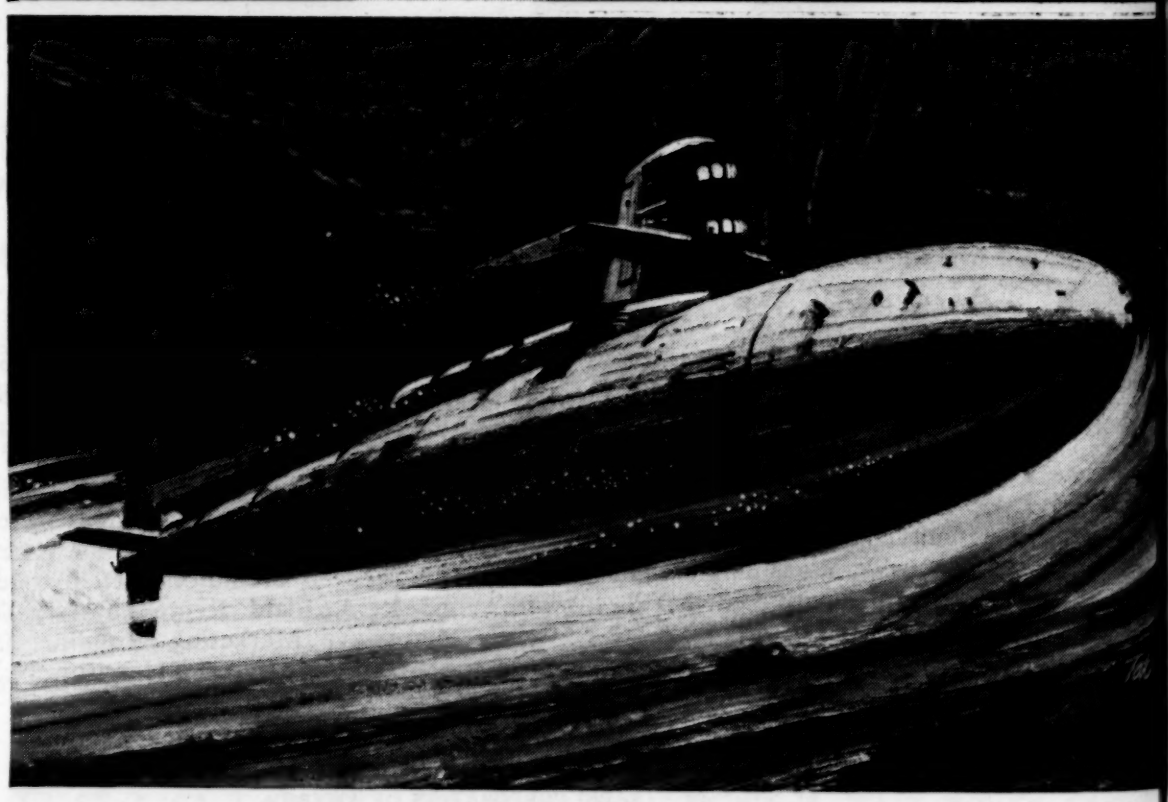
Circle Number 11 on Reader-Service Card

THE WONDER MATERIAL OF THE SPACE AGE IS PLASTICS

...AND THE COMPANY FOR PLASTICS IS ZENITH







From giant radomes...to radar antenna reflectors...to missile cases...to marine craft components...Zenith has the versatile capability to produce it *better* in plastics.

For more than 15 years, Zenith has pioneered new techniques and production processes in plastics. Today, Zenith has the most completely equipped reinforced-plastics laboratories and the most complete electronic test facilities for reinforced-plastics components in the world.

Zenith's production facilities include not only the usual plastics production equipment, but special equipment such as giant lathes, one of which is a hundred feet long. With equipment such as this, plus a wealth of engineering competence for design, tooling, fabrication, and testing, it is no wonder Zenith was called upon to make the giant radome for the Navy's Constellation, the largest airborne radome ever built. This is also why Zenith is making the tough plastics liner for the Polaris missile container.

Consider the many benefits of plastics in your aircraft, marine, and space projects before you seal the design. Remember, the wonder material of the space age is plastics...and the company for plastics is Zenith.

Minnesota Mining and Manufacturing Company

ZENITH PLASTICS DIVISION

1600 WEST 135TH STREET, GARDENA, CALIFORNIA

3M COMPANY

Circle Number 12 on Reader-Service Card

New Daystrom Series 319 Potentiometers Can Be Adjusted In Seconds After Ganging

It can be done. 24 cups of the Daystrom 319 Series potentiometers ganged within six inches. *Most important,* phasing of individual cups can be accomplished after installation, and with no interference to adjacent cups. Results: finite adjustments • many hours and dollars saved in installation costs • re-phasing in a matter of seconds!—■—The Daystrom 319 Series is ideal for multi-channel applications. Exclusive Daystrom design techniques result in unusual stability to shock, vibration, and other severe environmental influences. The 319 is rated at 2 watts in *still air,* operates over a range of −55°C to 150°C, is available in resistances from 100 ohms to 200 kilohms, and meets or exceeds all applicable MIL specs. Send for further data.

DAYSTROM, INCORPORATED
POTENTIOMETER DIVISION
ARCHBALD, PENNSYLVANIA • LOS ANGELES, CALIFORNIA

Circle Number 13 on Reader-Service Card

SPACE RENDEZVOUS

New PAT-C Applications Demonstrate Marquardt's Capability in Precision Controls

Typical of Marquardt's Control Systems capable of meeting the sophisticated requirements of today's weapon and scientific vehicles is the Corporation's Position-Attitude-Trajectory Control System.

Already selected for one satellite project, the Marquardt PAT-C System provides the exacting control required for space vehicle rendezvous. Whether it's an intercept, observation, maintenance, rescue, or destruction mission, PAT-C makes possible the accurate positioning of heavier payloads in space.

PAT-C is a highly responsive jet reaction system which controls the Position, Attitude and Trajectory of space vehicles as a result of inputs from the vehicle guidance system or ground control signals. The system provides the extremely precise corrective action based on simple position and velocity error signals, or will respond to the demand of guidance computers in the system. Tests demonstrating the flexibility of the PAT-C system range from multiple restarts up to 200 times per second to four minutes of continuous operation on a radiation cooled thrust chamber and nozzle.

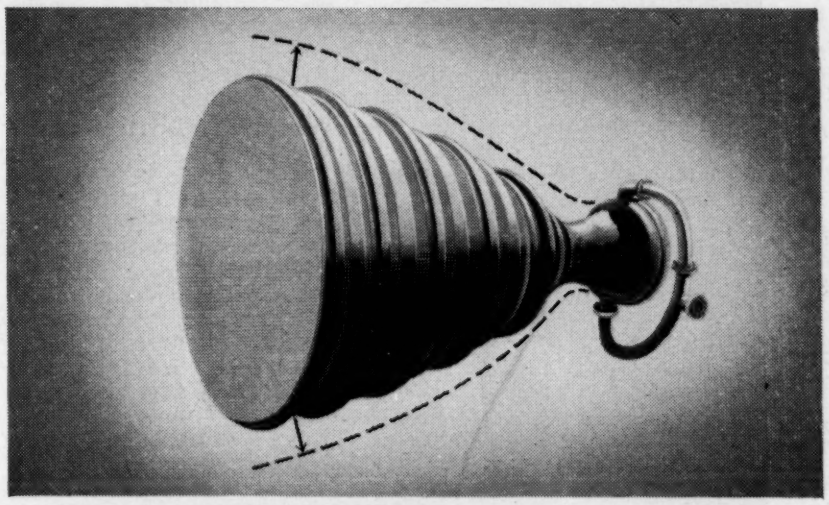
Marquardt's sixteen years of research and development has produced state-of-the-art advancements over a wide range of electronic, electro-mechanical, pneumatic, hydraulic and nuclear controls and accessories.

For example, products demonstrating the company's diversified capability include: gas operated servo systems for thrust vector control of an advanced ballistic missile; inlet controls for the McDonnell F4H-1 and the North American Hound Dog (GAM 77); a radically new space power unit; and control systems for the Bomarc ramjet engine and the Project Pluto nuclear ramjet engine.

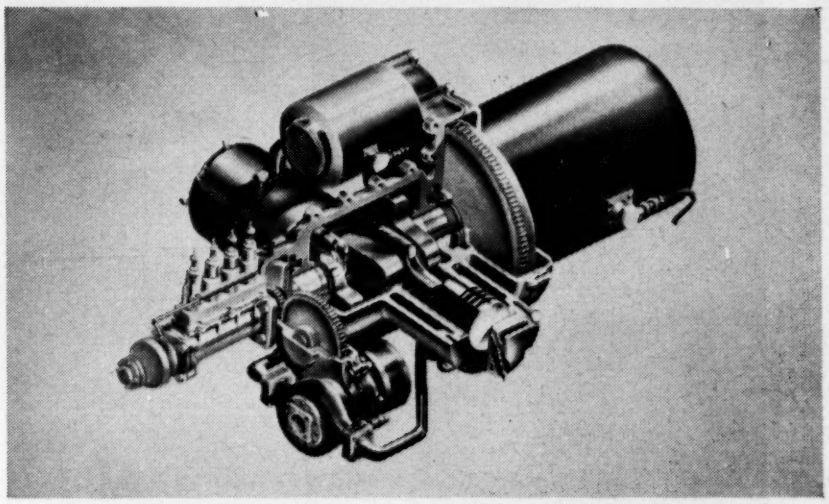
For additional information concerning the PAT-C system or controls capabilities contact Dick Oblinger, Chief Application Engineer.

Engineers and scientists experienced in these or related fields will find it rewarding to discuss their career futures with Marquardt, an equal opportunity employer.

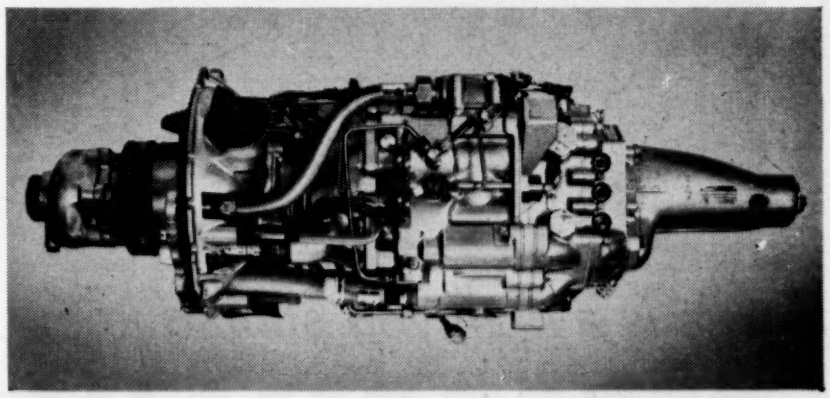
Circle Number 15 on Reader-Service Card



THRUST VECTOR CONTROL rotary actuators have been tested up to 1600 degrees F. and up to 42 hours.



SPACE POWER UNIT—a new Marquardt chemically fueled fixed displacement unit provides power with minimum weight for 1-15 day missions.

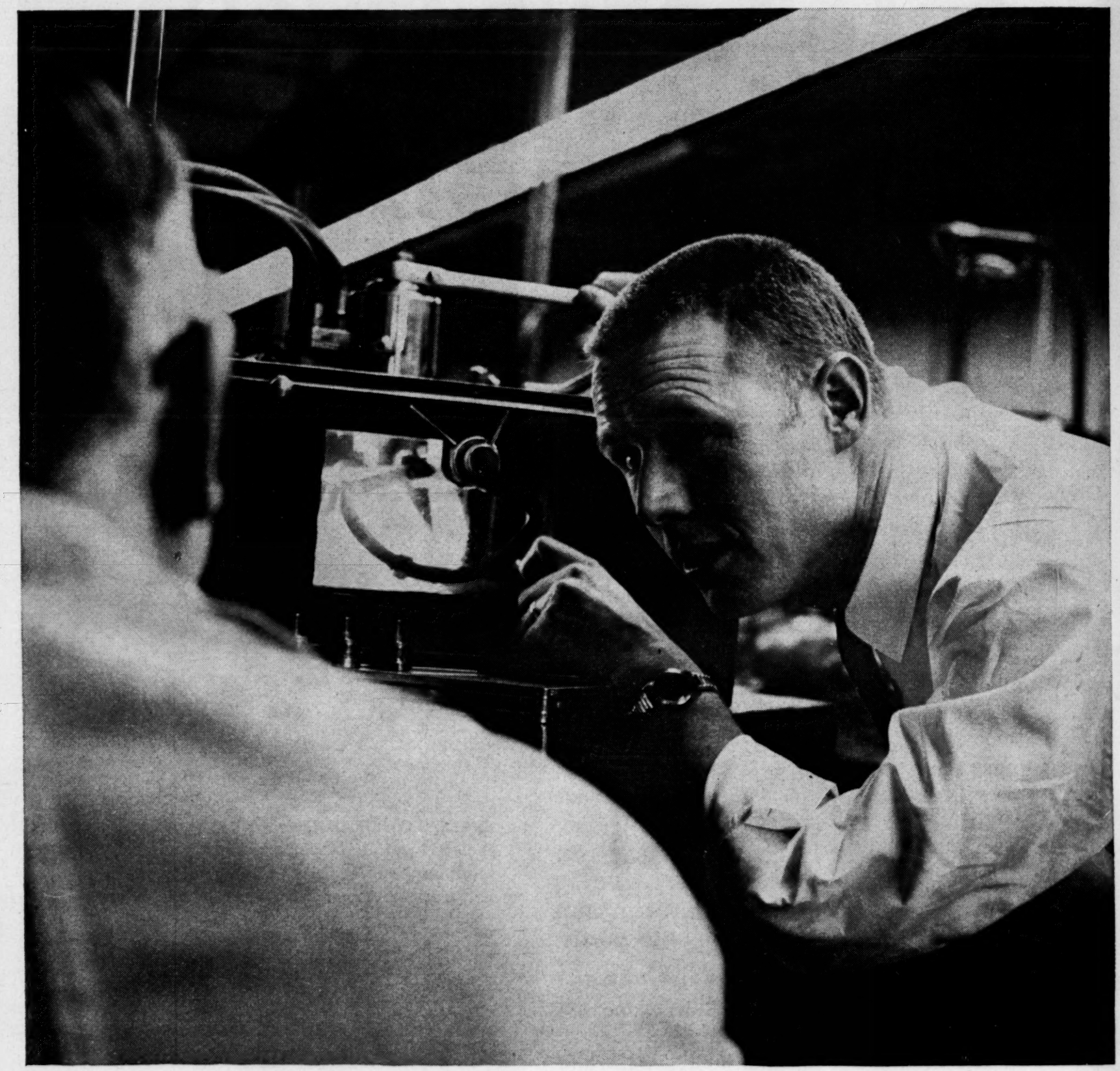


CONTROL PACKAGES utilizing ram air for all actuation and control functions are service-proven in operational weapons systems.

THE Marquardt CORPORATION

CORPORATE OFFICES: VAN NUYS, CALIFORNIA

ASTRO ◆ OGDEN DIVISION
◆ POMONA DIVISION
◆ POWER SYSTEMS DIVISION



this is a man you should know . . . a Delavan fuel injector specialist

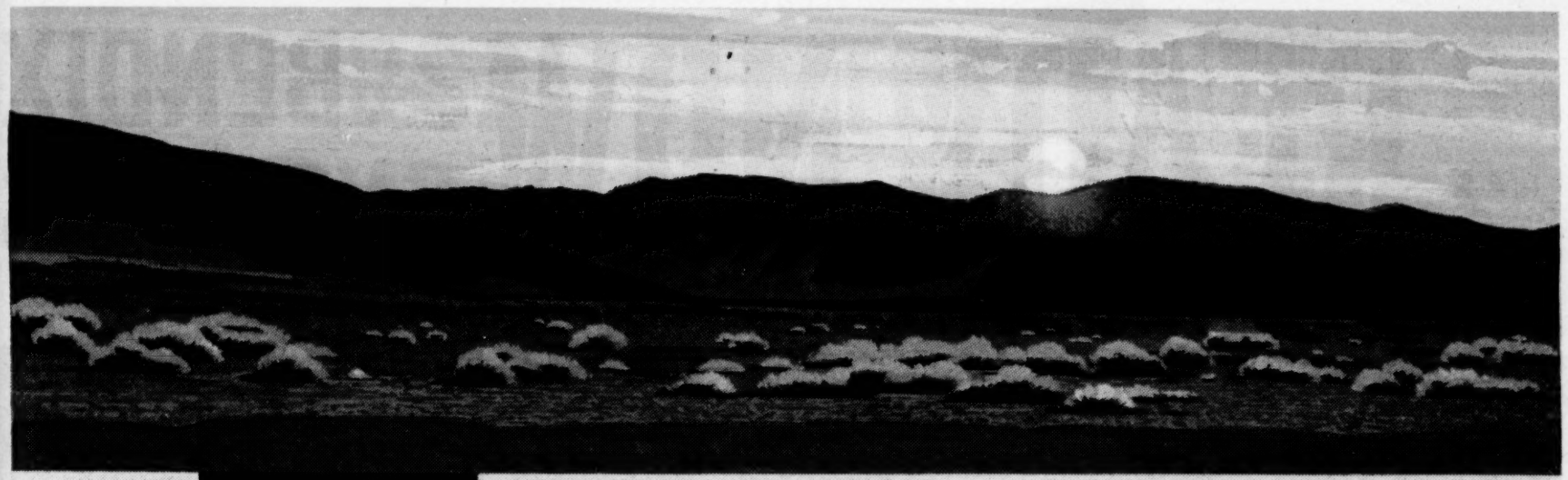
PERFORMANCE IS HIS RESPONSIBILITY

He is Richard O'Hara a Delavan Project Engineer who designs and develops after-burner fuel injectors and fuel nozzles. Ask him what kind of performance he wants from one of his fuel nozzle designs, he will tell you "The performance defined by customer specifications". And, this pretty well sums up the attitude of every member of Delavan's 40 man engineering department. Envelope dimensions, special tests, and reliability requirements are predetermined by you, the engine builder. Tell us these specifications and we'll design and manufacture your fuel nozzles . . . . on time and economically.

get to know Delavan fuel injector specialists

DELAVAN
Manufacturing Company
WEST DES MOINES, IOWA

Circle Number 16 on Reader-Service Card



SEALED IN A SECRET SILO

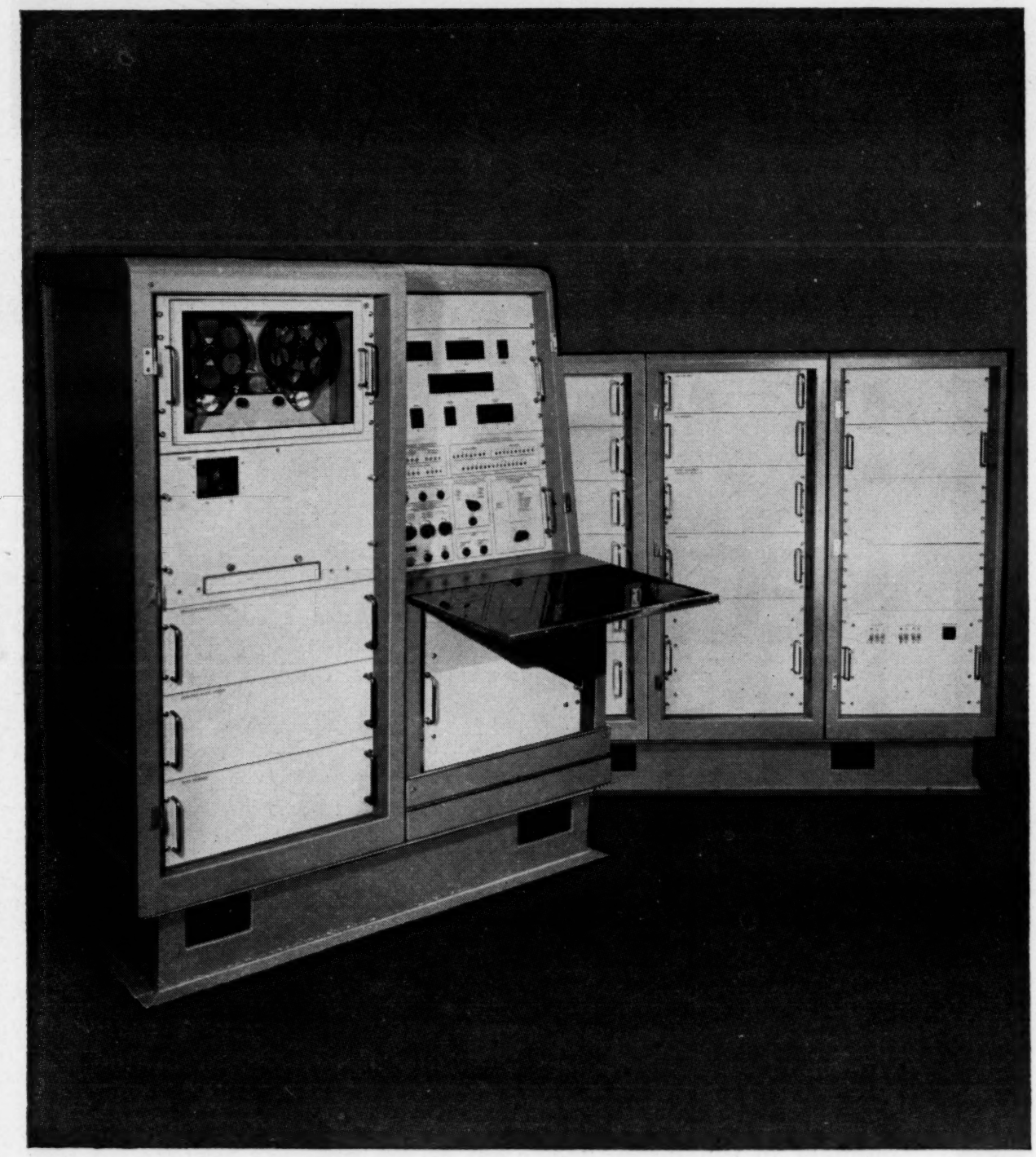
Somewhere in a wasteland, the Air Force Minuteman will keep its lonely vigil all through a thousand nights. Buried and untended, it must be ready to spring to life if the button is ever pushed.

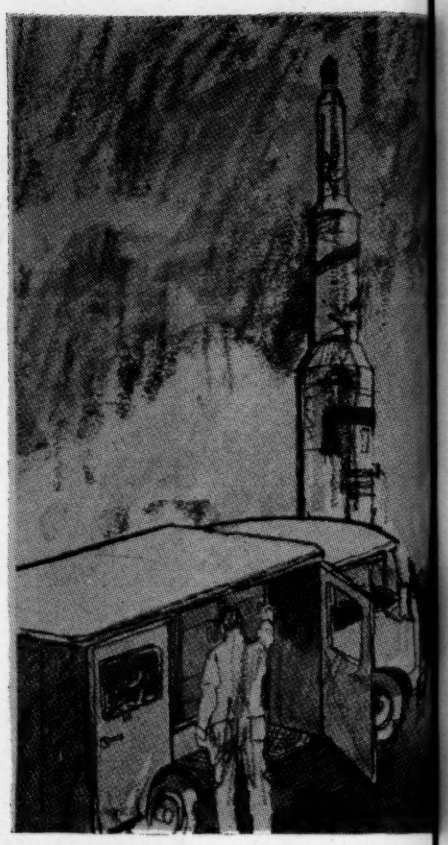
Minuteman poses a real challenge to the New Reliability — reliability which must guarantee successful firing at any moment in the far future. Each of the missile's systems, each of its thousands of electronic components, must function perfectly at that given moment. For once the missile is lowered into its silo, no human hands again need touch it.

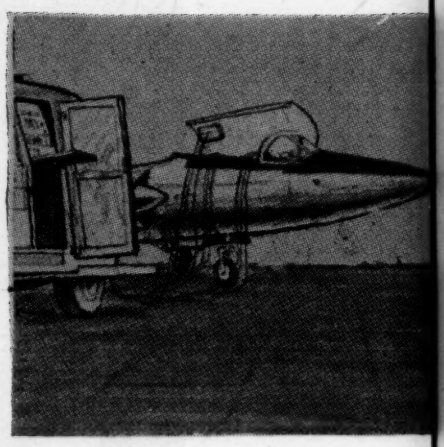
The Minuteman's critical guidance and control system has been entrusted to Autonetics. We are proud to be a member of this United States Air Force missile team.

Electromechanical Systems by Autonetics Division of North American Aviation

READY NOW ...BENDIX SYSTEMS







ADAPTABLE TO

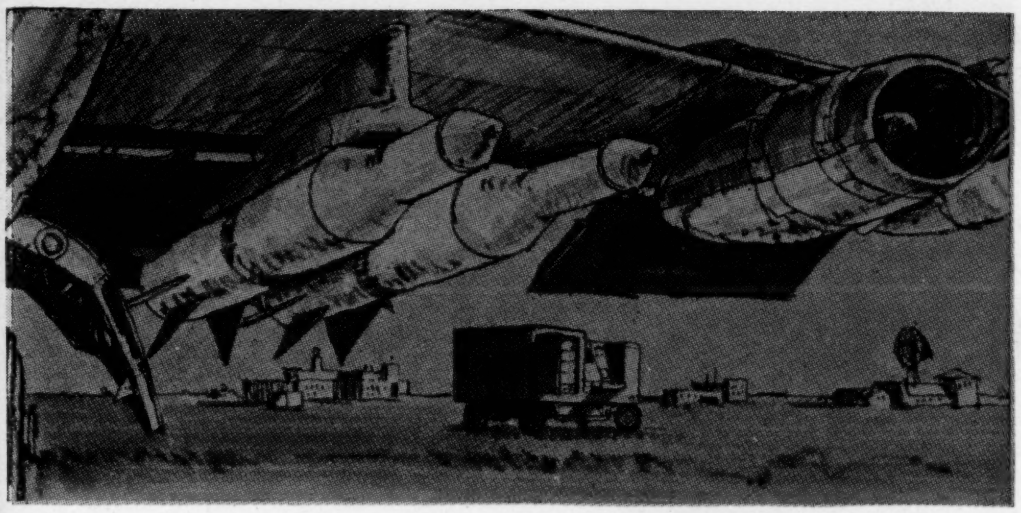
Knowmanship in Action

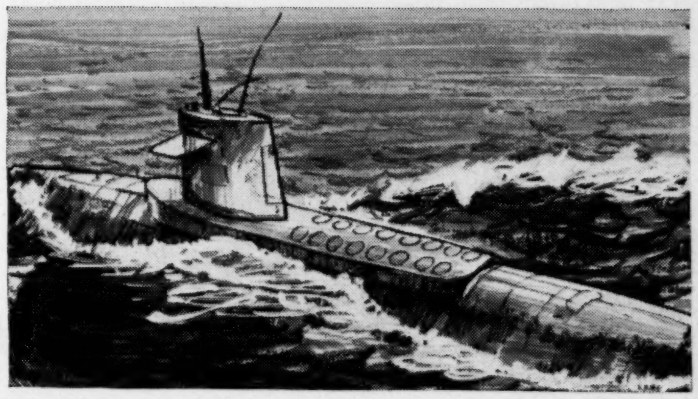
Now in quantity production at Bendix is a Universal Programmer-Comparator designed for automatic Go, No-Go, checkout of all types of air, land, sea, and space systems. Readily adaptable to electronic, hydraulic, mechanical, and pneumatic systems, it is tape controlled and has system logic capability for selecting hundreds of stimuli control channels and thousands of test points as required.

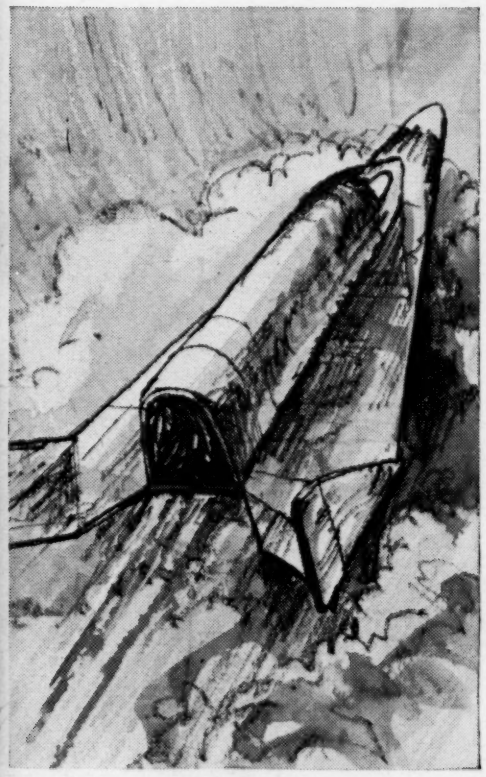
DISTINCTIVE FEATURES OF THE TESTER ARE:

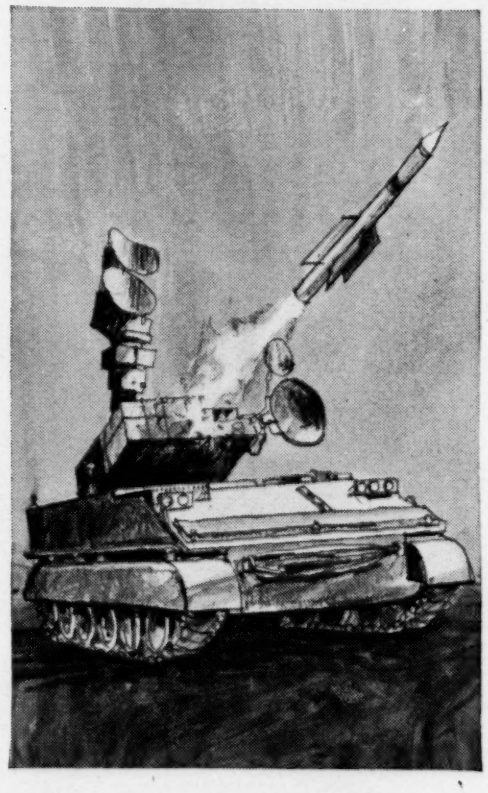
1. Checkout time for complex systems is reduced from hours to minutes. **2.** Minimum skilled technicians can perform complete systems checks with high accuracy. **3.** Visual display and printed record of the test results are provided for the entire testing sequence. **4.** Applicable to in-plant manufacturing as well as to all levels of maintenance activity. **5.** Modular construction permits packaging for either fixed or mobile units.

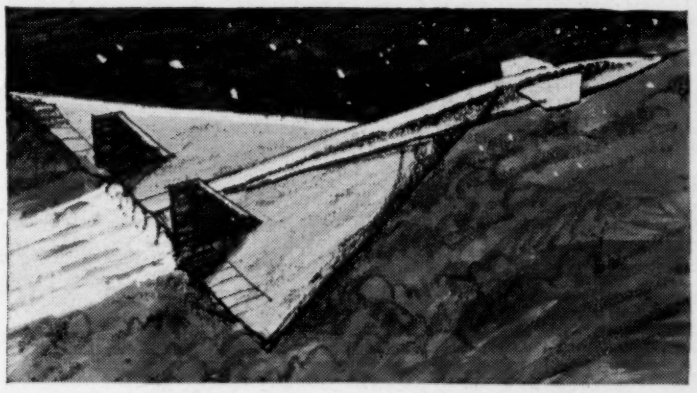
UNIVERSAL TESTER REDUCES CHECKOUT TIME TO MINUTES

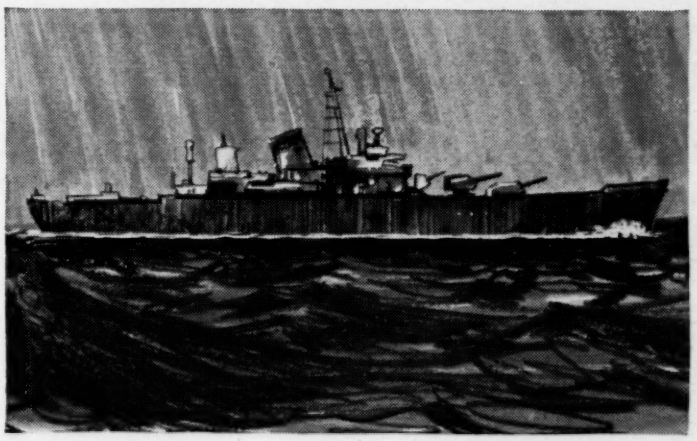












TESTING ALL TYPES OF AIR, LAND, SEA, AND SPACE SYSTEMS

The first application is the USAF's Douglas-built Skybolt Missile. Built to Mil-P-26664A, and designated AN/GJQ-9 by the USAF, the Universal Programmer-Comparator is available as Model PC-300 for commercial applications.

This Universal Tester is the latest Bendix achievement in the Support Equipment field and is another example of the engineering and production skills we have developed over a period of forty years. Whether the need is military or commercial, Bendix can provide the answer that does the job *best.*

TECHNICAL **KNOW**LEDGE + EXPERIENCED **MAN**AGEMENT + SPECIALIZED CRAFTSMAN**SHIP** = **KNOWMANSHIP**

For further information, write...

THE Bendix CORPORATION

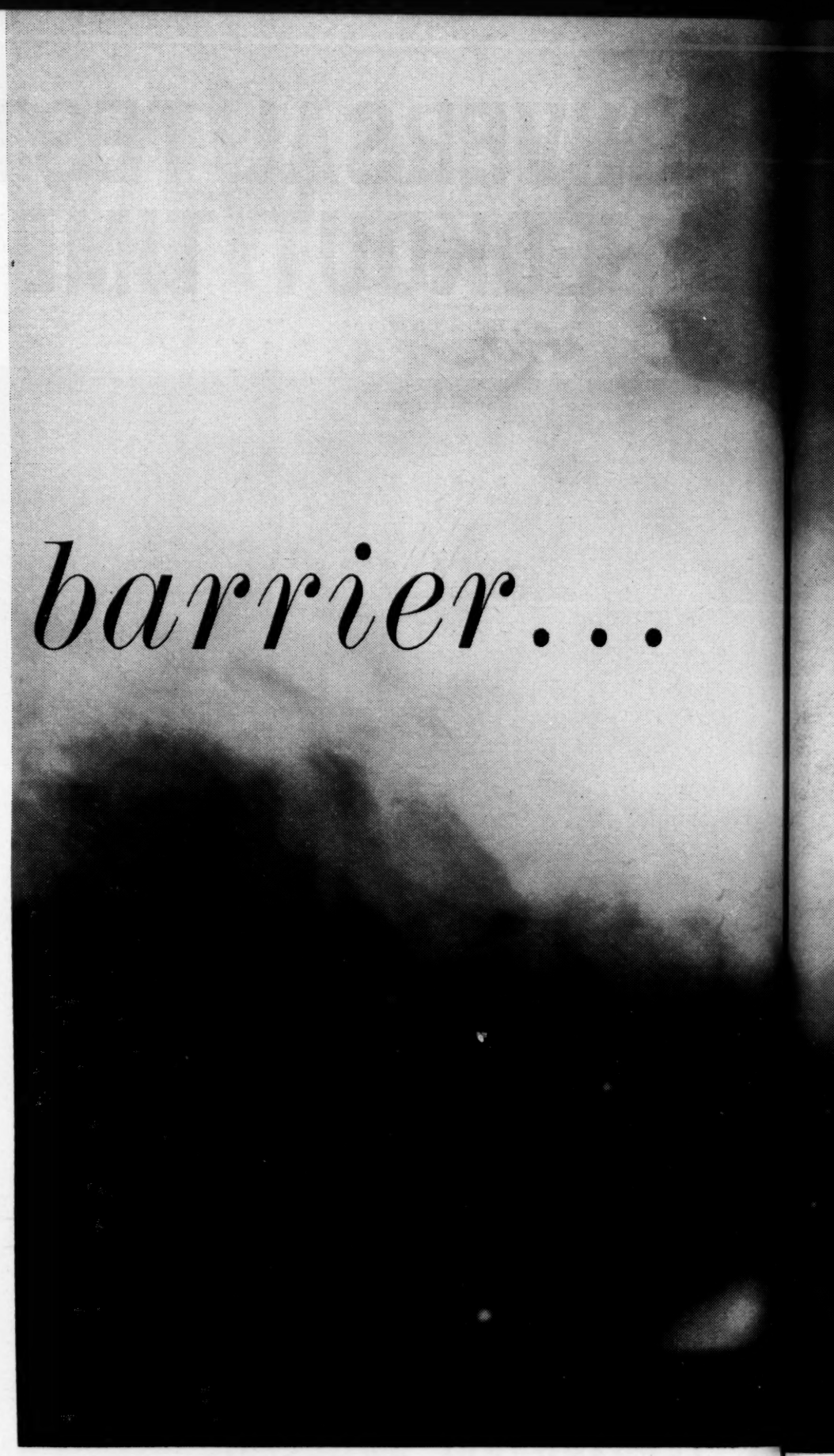
BENDIX SUPPORT EQUIPMENT

Eclipse-Pioneer Division

TETERBORO, N. J.

Circle Number 19 on Reader-Service Card

the breath barrier...



TO MEET THE LIFE SUPPORT REQUIREMENTS of long-duration space flights, a comprehensive, regenerable environmental control system will be needed. The primary design parameters: extreme reliability plus simple modular construction for easy maintenance. In addition, minute flow rates of liquids and gases must be metered under zero gravity conditions . . . improved components must be developed to prevent even infinitesimal leakage . . . proven techniques in systems dynamics and integration must be applied to assure dependability.

CURRENT HAMILTON STANDARD WORK in space life support is based on the use of many components which are presently within the state of the art. The entire space ECS design includes . . .

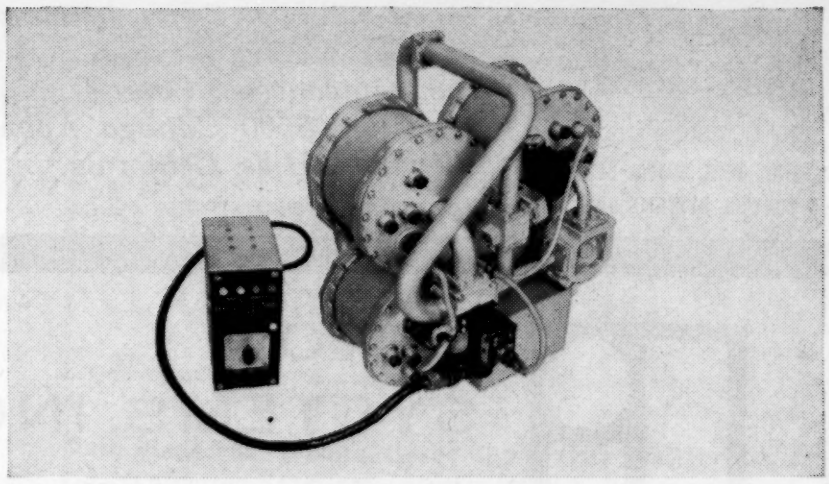
- a thermal control subsystem which utilizes a transport loop with aqueous ethylene glycol coolant to provide heat rejection to the ultimate sink.
- a contaminant and trace gas removal subsystem, utilizing conventional filter techniques, non-regenerable solid absorbents, or a unique regenerable solid adsorbent system, for removal of noxious and toxic gases.
- a partial and total pressure-control subsystem, operating from cryogenically stored fluids to provide a normal environment without special clothing.
- Instrumentation for monitoring all significant variables, plus emergency enunciation.
- Corollary subsystems which satisfy pre-launch, launch, mission, re-entry and emergency situations.

IN AN INTENSIVE PROGRAM begun three years ago, Hamilton Standard has already developed, built, and tested some of the basic equipment to be used. Moreover, a vast pool of fundamental research data has been accumulated which will greatly facilitate production of the system. This work is a logical evolutionary extension of experience that Hamilton Standard has amassed in the production of ECS for such advanced aircraft as the F-104, B-58, and B-70 —the most comprehensive system ever developed for manned flight.

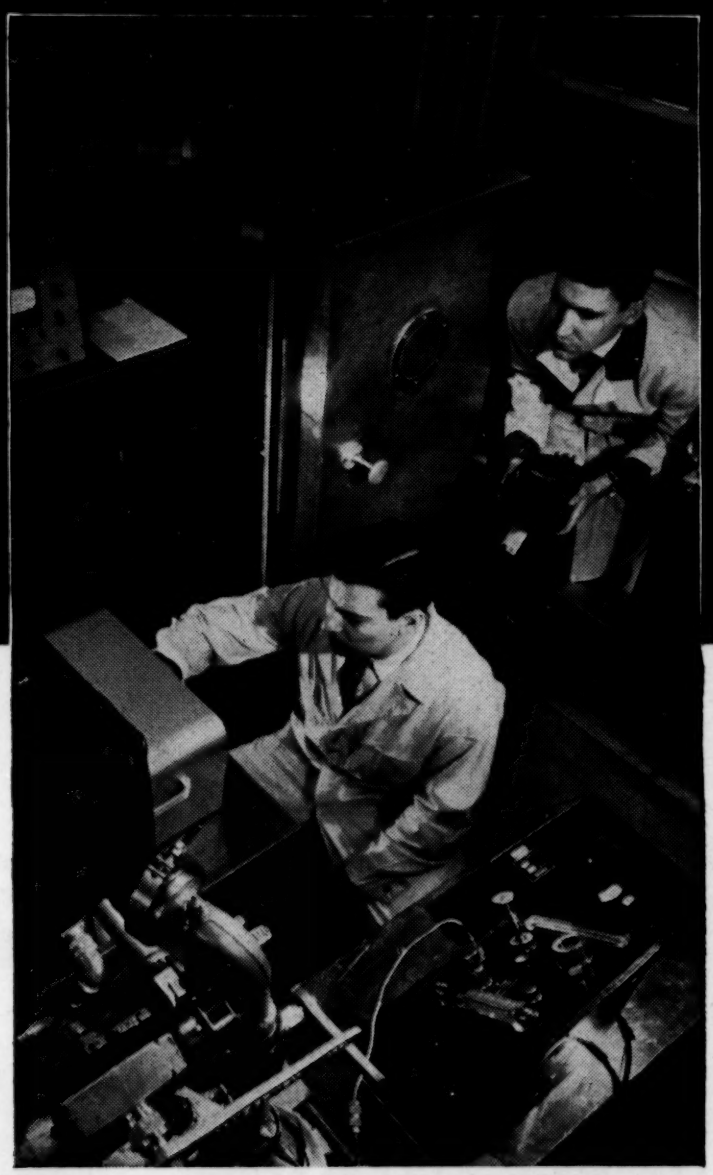
UNITED AIRCRAFT CORPORATION

HAMILTON STANDARD DIVISION

LIFE SUPPORT SYSTEMS



CO_2 REMOVAL UNIT could, in present form, sustain three men in a sealed capsule indefinitely. Several of these units, have already accumulated hundreds of hours of testing. One assembly, operating under a 3-man load in the Moon Room, recently passed 100 hours of continuous endurance testing, and is scheduled for further tests by NASA.



MOON ROOM, a 550 cubic foot closed environment laboratory, simulates isolated-cabin conditions for up to five men. Here, Hamilton Standard has performed development tests involving weight, configuration, volume, power requirements, and reliability of a variety of space ECS equipment.

Circle Number 21 on Reader Service Card

CREATIVE CONTROVERSY IN INERTIAL GUIDANCE

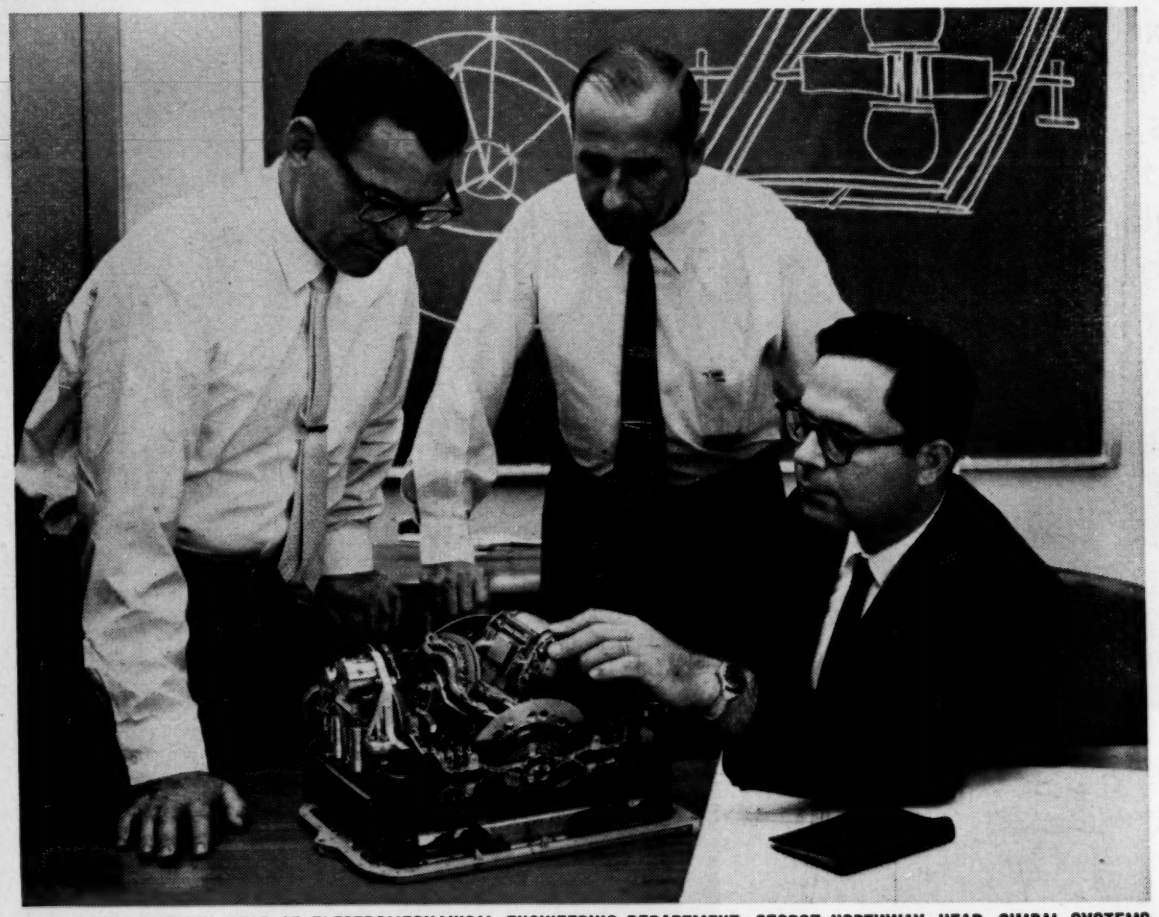
Behind the inertial package you see here is the instructive history of a creative controversy.

It's the history of how the ingenious rebuttals of some Litton Systems people won an engineering debate by overcoming certain obstacles that had been roadblocking progress in airborne inertial navigation.

The equipment shown is the stable-platform unit of a Litton LN-3 navaid system, first to furnish operational aircraft with inertial navigation information to an accuracy within 1.5 nautical miles for each hour of varied flight maneuvers.

The debate: It had been known that an inertial platform could be built around two two-degree-of-freedom gyros in place of the three one-degree-of-freedom gyros that were the standard concept. And that such a change would offer a number of important advantages including high gyro angular momentum in a compact platform, better servo response characteristics, and freedom from air-bubble problems achieved through the use of low-viscosity damping fluid.

Many inertial engineers felt strongly that the difficulties encountered in trying to manufacture two-degree-of-freedom gyros would more than offset the promised benefits. The difficulty regarded with the most superstitious awe was the problem of adjusting the center of gravity, center of buoyancy and total weight of the float containing the gyro to achieve neutral buoyancy at a specified temperature and zero torque about all three axes, within extremely narrow tolerances.



L-R: BRUCE SAWYER, HEAD OF ELECTROMECHANICAL ENGINEERING DEPARTMENT; GEORGE NORTHWAY, HEAD, GIMBAL SYSTEMS ENGINEERING; HAROLD ERDLEY, DIRECTOR OF ELECTROMECHANICAL PRODUCTS, GUIDANCE & CONTROL SYSTEMS DIVISION.

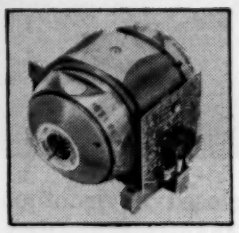
The additional restriction, that the weights placed on the float for balancing shall fall between a minimum and a maximum allowable size, increases the complexity of the actual balance procedure, placing it in the "linear programming" category from a computer standpoint.

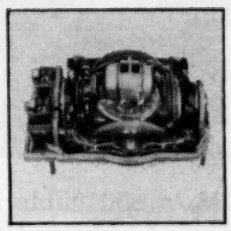
The problem was solved by being programmed for solution on a digital computer in order to provide an efficient and reliable balancing process in production. The success of this approach is demonstrated by the world-wide operation of the Litton LN-3 aircraft navigation system, a proven lightweight system of high accuracy that uses two-degree-of-freedom gyros.

The same approach is being used to expedite the development of even more advanced systems, which will assure Litton's dominant position in the field. They include the Litton Doppler-Inertial System for the P3V anti-submarine patrol aircraft and the P-300 inertial platform of the Air Force Flight Data System for orbital and sub-orbital vehicles.

It's good to work in the atmosphere engendered when management fully appreciates the value of creative controversy that produces such results. Like-minded design and production engineers with applicable experience couldn't do better than to contact N. M. Pagan, Litton Systems, Inc., Guidance & Control Systems Division, 5500 Canoga Avenue, Woodland Hills, California.

An equal opportunity employer





LITTON SYSTEMS, INC.

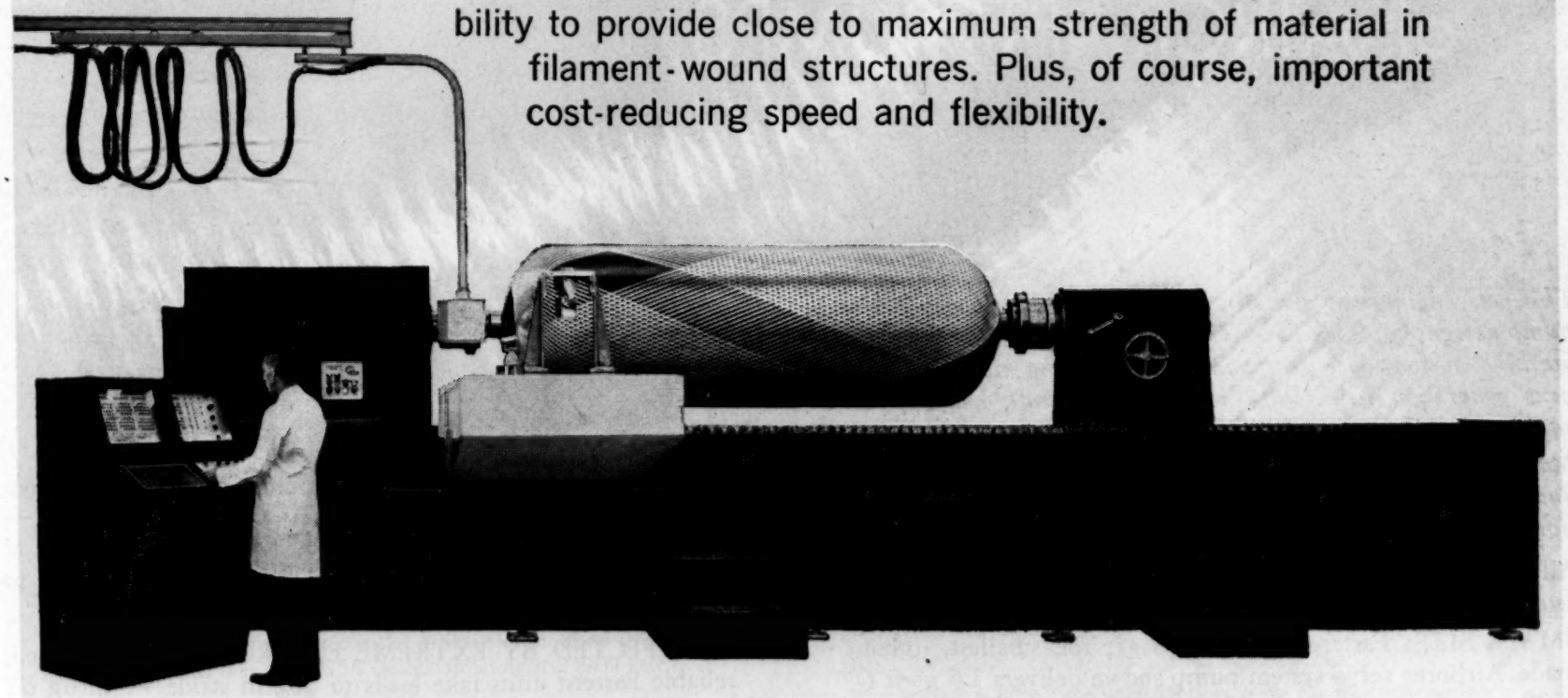
A DIVISION OF LITTON INDUSTRIES

GUIDANCE & CONTROL SYSTEMS · COMPUTER SYSTEMS · DATA HANDLING & DISPLAY SYSTEMS · SPACE SCIENCE · BIOELECTRONICS · ADVANCED COMMUNICATIONS TECHNOLOGY

Circle Number 22 on Reader-Service Card

ROHR WINDS UP LEADING THE FIELD

The industry's first tape-controlled, continuous-path filament winding machine is in full production now. Designed and built by Rohr, it wraps glass fibre filaments with amazing precision to form lightweight structures of great strength, such as the rocket motor case shown below. It is capable of winding parts up to 25 feet in length and 8 feet in diameter — and has the ability to wind an infinite variety of patterns, including a continuous filament pattern for multiple-nozzle motor cases. Actually, the wrapping of different pressure vessels is as simple as changing the tape. This advanced machine demonstrates Rohr's unique skill in designing and building highly specialized manufacturing equipment... plus knowledge gained from years of programming and production of three-dimensional parts by numerical control. The ability to produce precision-wound products on this new filament winding machine demonstrates the breadth of our research into plastics and adhesives and the depth of our experience in collapsible mandrel manufacture. Because it achieves such precise and uniform positioning of filaments, this Rohr machine now offers the industry the capability to provide close to maximum strength of material in filament-wound structures. Plus, of course, important cost-reducing speed and flexibility.

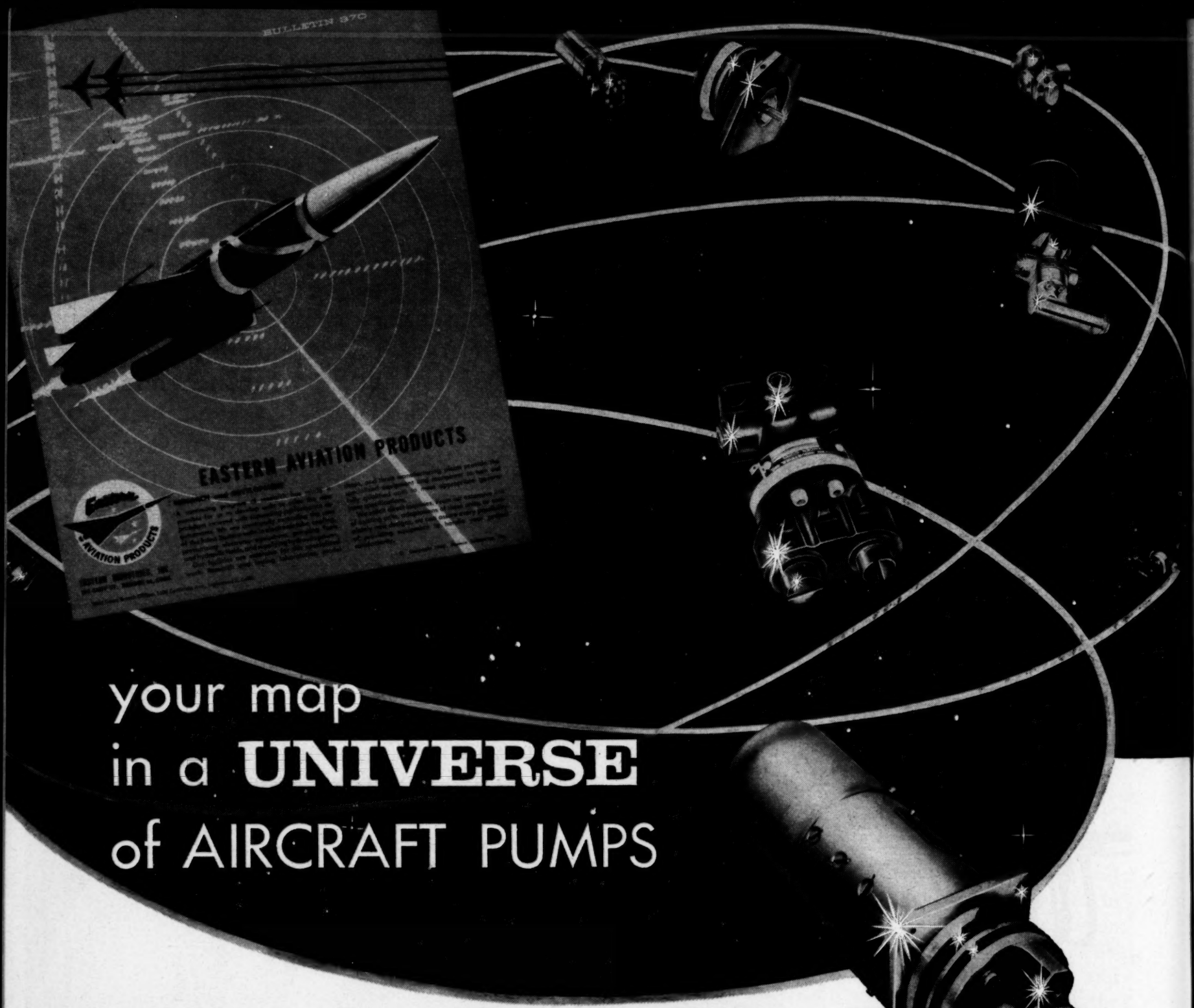


ROHR NUMERICALLY CONTROLLED FILAMENT WINDING MACHINE

For information on this and other Rohr production techniques please write Mr. A. R. Campbell, Sales Manager, Dept. 61, Rohr Aircraft Corp., Chula Vista, Calif.

Main Plant and Headquarters: Chula Vista, California / Plant: Riverside, California / Assembly Plants: Winder, Georgia; Auburn, Washington

ROHR
AIRCRAFT CORPORATION



your map in a UNIVERSE of AIRCRAFT PUMPS

This new engineering bulletin leads you right to the hydraulic pump designs you may be looking for. Here, passing on parade, are high performance gear pumps made to the measure of the next generation in aircraft, missiles, spacecraft, and support equipment.

Many of these units are the product of ready-made, mass-produced components that can be teamed into the precise configuration you need. Custom-designed pumps are also available.

All have in common these classic Eastern hydraulic pump characteristics:

SMALL SIZE: Eastern gear pumps are the smallest, lightest made. Airborne servo system pump shown delivers 1.5 gpm @ 1500 psig — measures only 1⅞" x 1⅞" x 2¾", weighs 9 oz.

WIDE PERFORMANCE RANGE: pumps available have theoretical displacement from .0016 to 1.30 cu. in. per revolution — flow from .025 to 9.6 gpm, pressures from 0 to 2000 psig, at speeds to 24,000 rpm. Weights with motor range from 1.5 to 8.5 lbs.

UNAFFECTED BY EXTREME ENVIRONMENTS: rugged, reliable Eastern units take loads to 50g in stride — shrug off temperature differentials to meet MIL specs.

Eastern AVIATION PRODUCTS

EASTERN INDUSTRIES INCORPORATED

100 SKIFF STREET • HAMDEN 14, CONNECTICUT
WEST COAST OFFICE • 4203 SPENCER ST. • TORRANCE, CALIF.

Other Eastern products:
- **hydraulic motors**
- **servovalves, amplifiers, actuators and systems**
- **pressurization/dehydration packs**
- **quick-disconnect couplings**
- **electronic tube cooling units**

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● From Miami to Jacksonville, from Naples to Pensacola . . . Florida is the booming aviation state.

Aircraft overhaul . . . Small plane manufacturing . . . Jet engine testing . . . Electronics . . . Components for missiles and rockets . . . Engineering & design . . . Research & development . . . Space technology . . . Cargo for the world's markets.

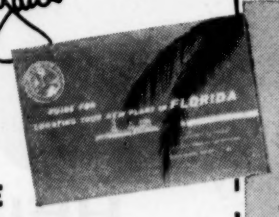
From Cape Canaveral to Eternity, Florida is the space age state. Find out why, and we'll see you at the crossroads of the skies . . . Florida . . . the best place on earth for your new facilities!

FLORIDA'S ASSURANCE POLICY

You have my personal assurance of a sunny business climate here in Florida. You have positive assurance of every aid and assistance possible from our Florida Development Commission and from the overwhelming majority of our businessmen, industrialists, and financiers. We have everything to make your large or small enterprise healthy and successful. Write, wire or phone us today. The only thing better than a FLORIDA vacation is having your plant here."

Governor, State of Florida

FLORIDA FOR CONVENTIONS — Write for free information on Florida's wonderful facilities for your group meeting.



Mr. Wendell Jarrard, Chairman
FLORIDA DEVELOPMENT COMMISSION
Box 4119A, Tallahassee, Florida

Please send me "Plant Location Guide," containing all the facts about Florida's opportunities for New Industry, the *10 Billion Dollar Consumer Market*, Labor, Climate, Schools, Natural Resources, Favorable Tax Structure.

Name .....

Firm Name .....

Address .....

City ..... Zone ..... State .....

INVESTIGATE DEBT FREE

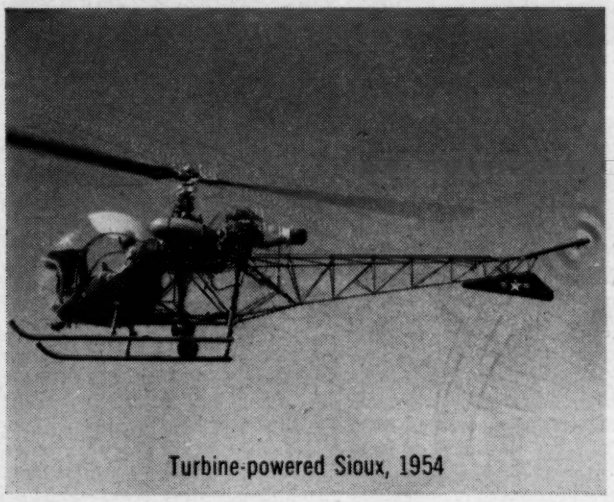
Florida

A 10 BILLION DOLLAR MARKET

Ask about free film "Profile of Progress."

←Circle Number 24 on Reader-Service Card Circle Number 25 on Reader-Service Card

LOOK TO **BELL** FOR LEADERSHIP, TODAY AND TOMORROW, IN


Turbine-powered Sioux, 1954

T-53 turbine-powered XH-40, 1956

T-63 turbine-powered HUL-1-M, January, 1961

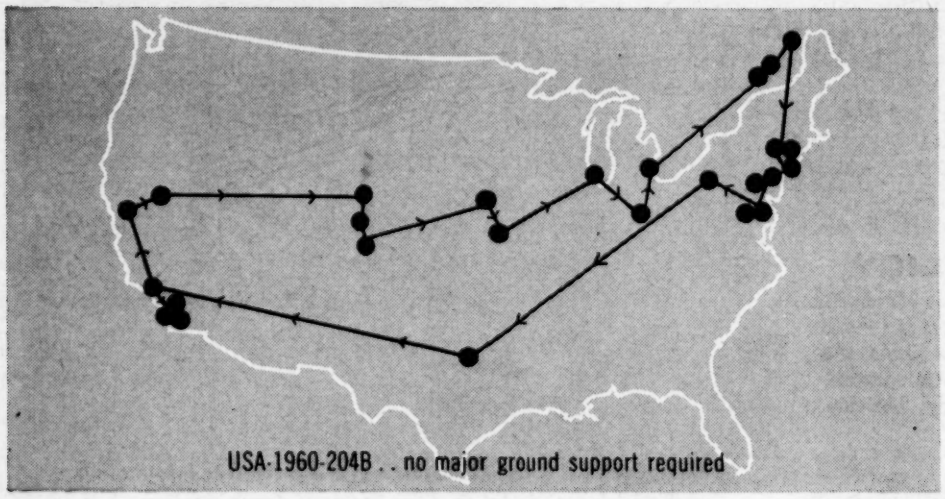
TURBINE-POWER DEVELOPMENT..IN CONTRACT PERFORMANCE..

Turbine-powered OH-50 (LOH) 1961

MISSION BELL ACCOMPLISHED

Iroquois deliveries on schedule

IN GLOBAL FLIGHT RELIABILITY..IN WORLD FLIGHT RECORDS


USA-1960-204B . . no major ground support required

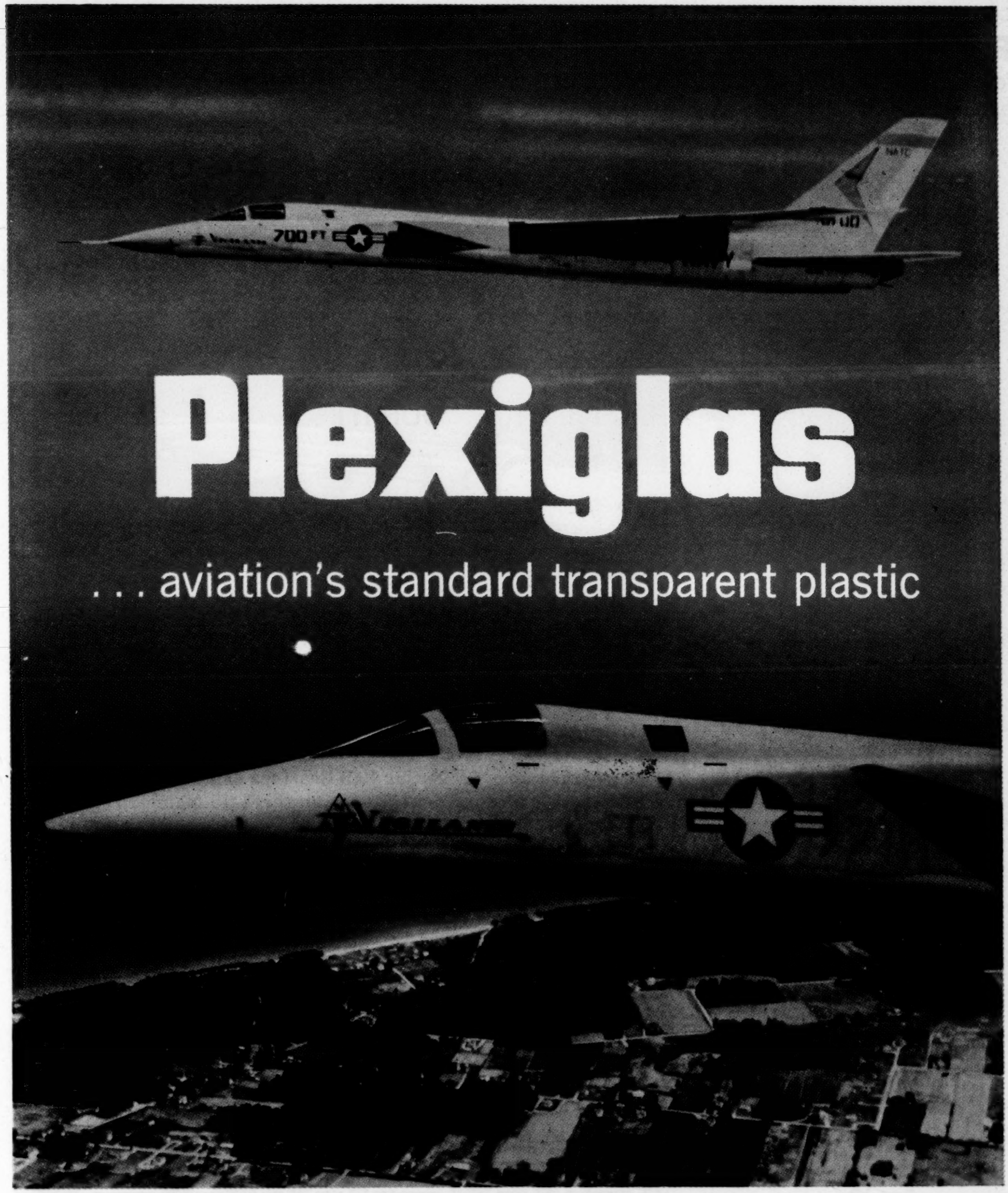
4-Place 47J on speed run

Bell's proven production leadership has provided helicopters of greater reliability, dependability and economy. And consistent achievement of schedules, contract prices and mission-suitability has kept Bell a part of the Army's tactical helicopter plan. The Army's superior front-line aviation capabilities are evidence of this successful Army-industry relationship.

BELL HELICOPTER COMPANY FORT WORTH, TEXAS

A DIVISION OF BELL AEROSPACE CORPORATION

A textron COMPANY



On the North American A3J Vigilante, new Navy all-weather attack aircraft with speed in the Mach 2 range, PLEXIGLAS 55 *acrylic plastic is used for the curved windshield and pilot's canopy.*

WHERE THERE'S PROGRESS, THERE'S PLEXIGLAS®

ROHM & HAAS

PHILADELPHIA 5, PA.

In Canada: *Rohm & Haas Co. of Canada, Ltd., West Hill, Crystal Glass & Plastics, Ltd., Toronto*

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Look to
FAFNIR
for leadership in
ball bearings

Where heat is your problem...

Some bearings "freeze" under prolonged high heat. When they do, performance drops off . . . costs rise . . . and the heat's on *you!* The answer? Fafnir Ball Bearings engineered for high temperature service. For instance, in the X-15 manned rocket, they're used by the hundreds at critical points. So, when you're up against heat . . . or *any* bearing problem . . . look to Fafnir for the diversity, the capacity, the research to find your answer. The Fafnir Bearing Company, New Britain, Connecticut.

"MADE IN U. S. A."

This stamp on a Fafnir Ball Bearing means finest quality and workmanship . . . dependable supply . . . competent engineering help . . . and **responsibility** in meeting your bearing needs. It's worth bearing in mind.

FAFNIR
BALL BEARINGS

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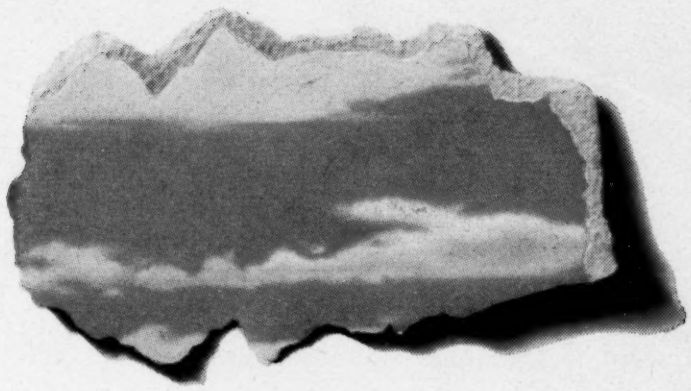
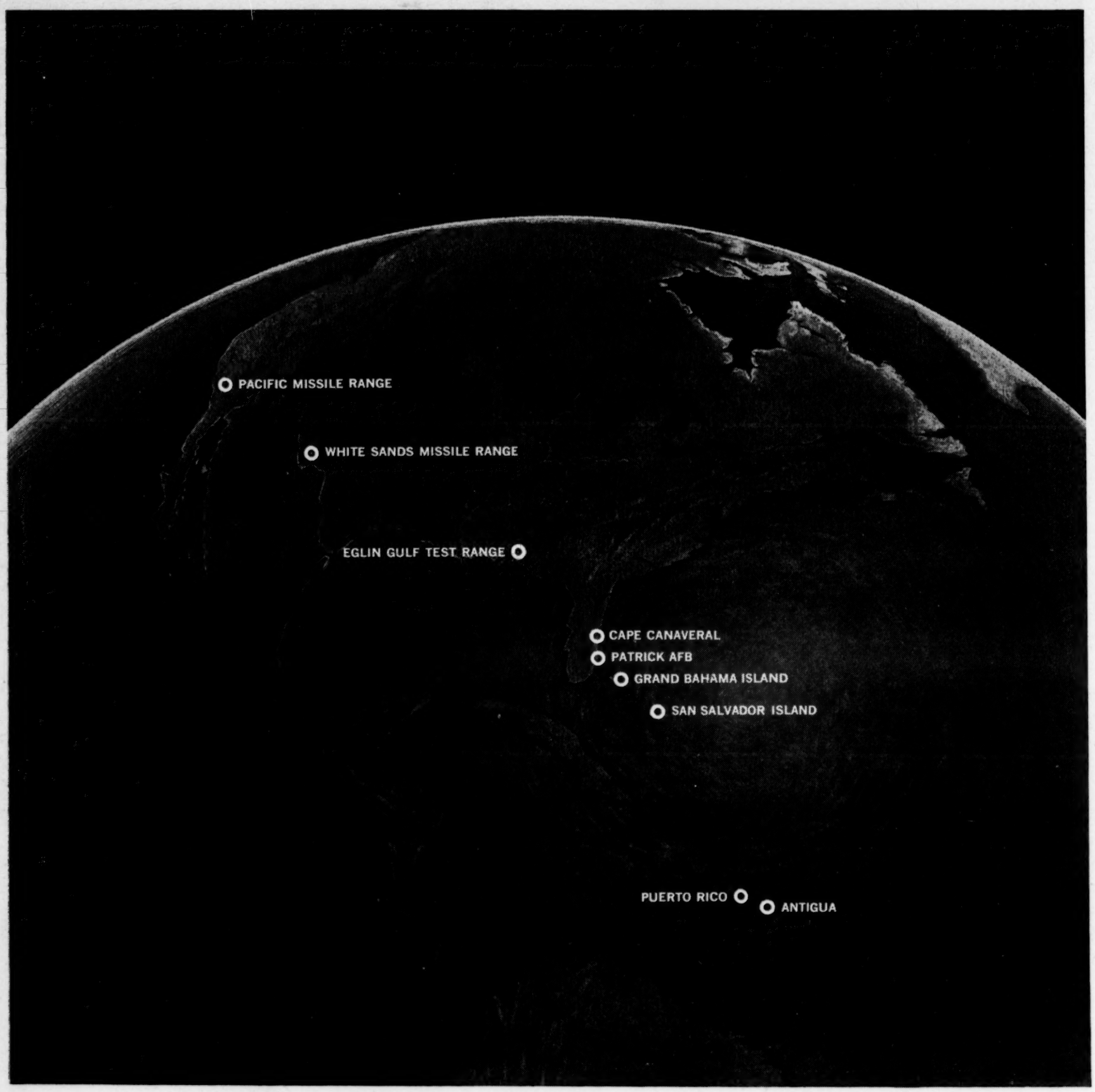


Problem for Skybolt: Where is this patch of sky?

To calculate its trajectory to target, Skybolt air-launched ballistic missile will have to know precisely where it is at any given moment, day or night. This problem is neatly solved by the star tracking capability of its Astronertial guidance system, which can provide an instantaneous fix on any piece of sky the mother plane passes through. When Skybolt is operational, the guidance system will put it into a ballistic trajectory after launch, to deliver the warhead on target up to 1000 miles away.

This versatile stellar-monitored inertial guidance system is being designed and built by Nortronics for the USAF-Douglas Skybolt, now under development.

NORTRONICS
A DIVISION OF
NORTHROP



Soon! Cubic DHE on every major missile range

A recent Air Force Missile Test Center $1.7-million award to Cubic means that the company's advanced DHE (Data Handling Equipment) will soon be functioning on every major U.S. missile range. Under previous contracts, Cubic developed-and-produced DHE has already been installed on the Eglin Gulf Test Range (Air Force), White Sands Missile Range (Army), and Pacific Missile Range (Navy). The new digital data system for AMR will transmit position information up and down the chain of radars stretching between Cape Canaveral and five downrange stations, facilitating radar acquisition of missiles, satellites, and space vehicles. *A variety of equally challenging space age projects at Cubic offers interesting employment opportunities to scientists and engineers; qualified applicants will receive consideration without regard to race, creed, color, or national origin.* For further information on Cubic or its products, write Department AW-109.

cubic CORPORATION

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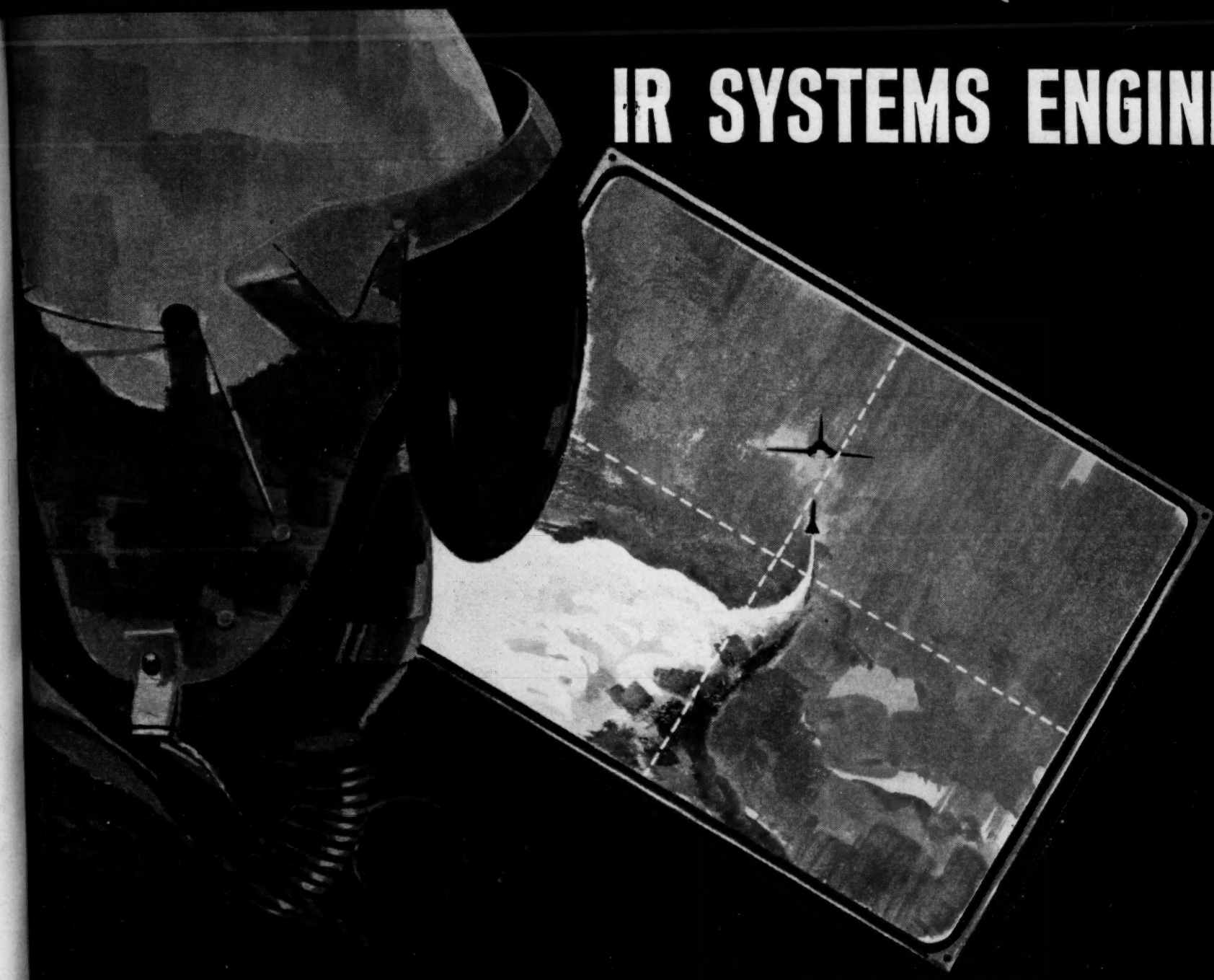


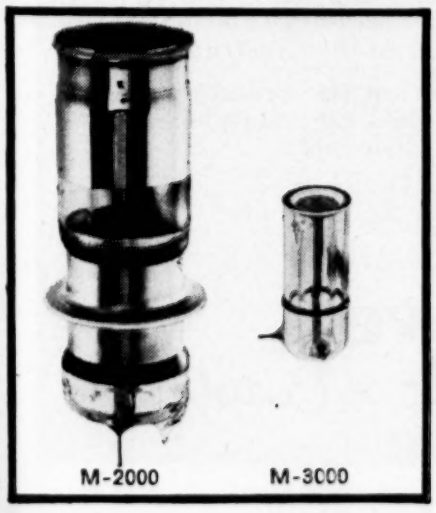
IR SYSTEMS ENGINEERS

TI INFRARED DETECTORS WILL IMPROVE YOUR IR SYSTEMS

With Detectivities Through 15×10^9/Excellent Detector Stability/High Reliability*

Take advantage of Texas Instruments volume production experience and achieve the high performance standards your IR systems demand with TI high-sensitivity indium antimonide infrared detectors! The high reliability of these photovoltaic detectors has been proved by many months of actual service in our nation's most advanced weapon systems . . . you can be confident of electrical, mechanical and performance uniformity. Ideal for use with transistorized circuits, both the M-2000 and M-3000 series are designed to operate at liquid nitrogen temperature, and within the two to five micron range. Both detectors feature low noise/high responsivity and utilize painted lead and *kovar* pin construction to assure high electrical circuit reliability. Compactly packaged, the M-3000 series weighs only five grams and is especially designed to withstand strong vibrational stresses. The laboratory-sized M-2000 weighs 38 grams. Specify these cooled indium antimonide IR detectors today for your volume production, high reliability infrared systems.

**Test data on large quantity production lots is available on request.*



electrical characteristics at minus 196°C

Parameter	Detectivity and Impedance Ranges Available				
Detectivity (D★)	$\geq 4 \times 10^9$	$\geq 6 \times 10^9$	$\geq 9 \times 10^9$	$\geq 12 \times 10^9$	$\geq 15 \times 10^9$
Small Signal AC Impedance (ohms)	≥ 500	$\geq 1K$	$\geq 2K$	$\geq 3K$	$\geq 4K$

Time Constant.....less than 1 microsecond Spectral Response.....2 to 5 microns

D★....dependent on area (minimum 4×10^9 at optimum bias)

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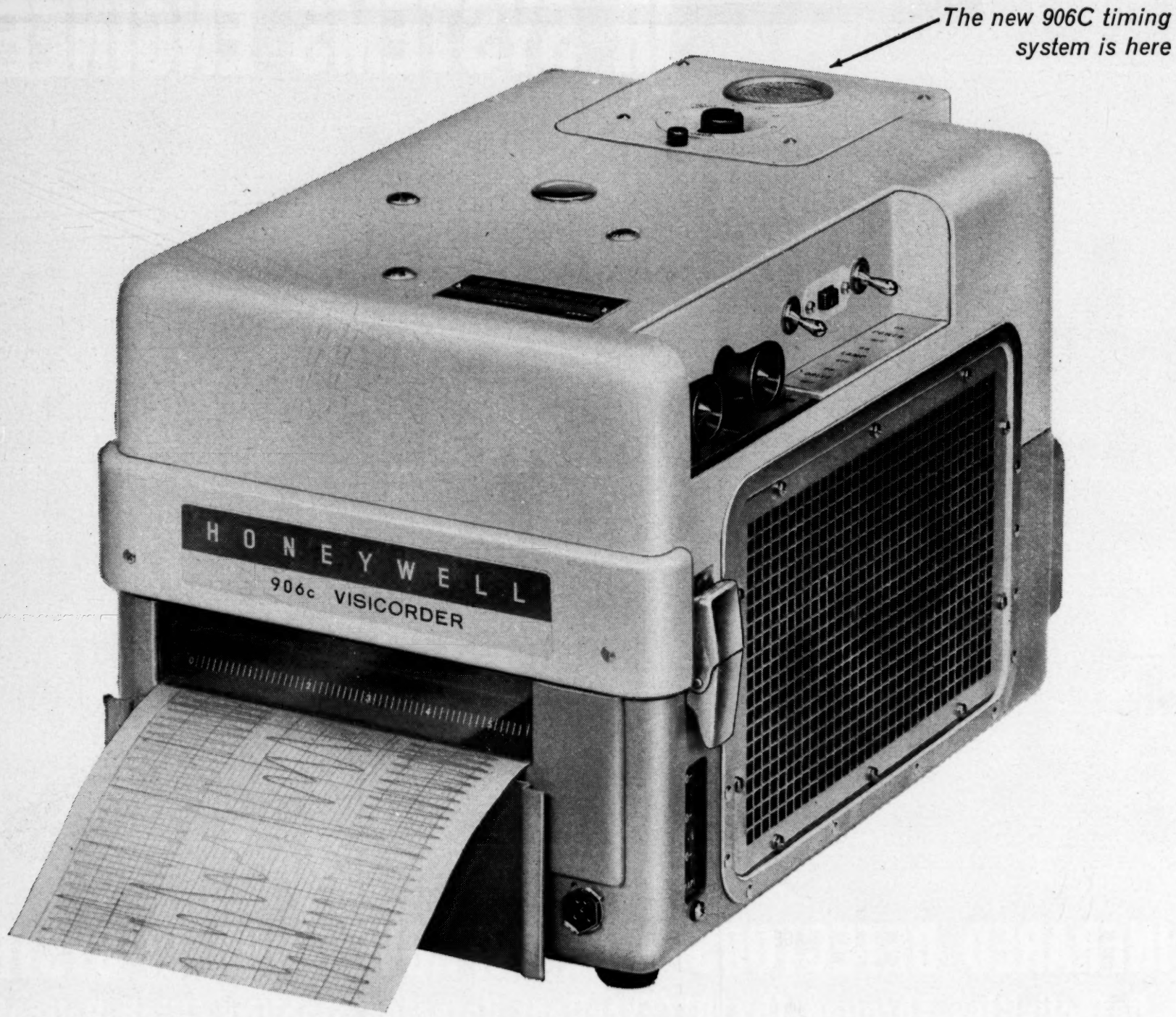
17927



What's *different* about the NEW 906C VISICORDER OSCILLOGRAPH?

At first glance you may see no difference at all. Just the same functional lines and compact size that you have come to recognize in the Visicorder.

They have not changed since 1956, when the Visicorder principle of oscillography made immediate readout of high frequency data possible for the first time.

Until now, all the improvements that have maintained the Visicorder's record of leadership have been internal:

—increased capacity to 14 channels
—higher frequency response (0-5000 cps)
—simultaneously recorded grid lines
—self-starting lamp for remote operation

But the 906C has a new feature you *can* see, (look carefully at the back of the case) and one that represents still another breakthrough; a built-in flash tube timing system which not only generates its own time base, but which can also be triggered *externally*. You can, in other words, use the 906C's timing system to record time lines simultaneously with data. Or you can trigger the timing circuit externally—either by supplying a pulsing voltage of only +10v into 20K ohms impedance, or simply by causing impedance to drop to 100 ohms or less through shorting-out or other means.

Thus your "time" signal may actually be an event marker related to shaft rotation, belt movement, or any other effect which might be more conveniently fed to the timing circuit than to a galvanometer.

(Owners of Visicorders 906, 906A, and 906B will be glad to know that only a *field-change* is necessary to economically and easily add this timing system to their instruments).

Write today for full information on the brand-new 906C Visicorder. Ask for Catalog HC-906C. Or call us at SKyline 6-3681, Direct Distance Dialing Code 303.

Minneapolis-Honeywell, Heiland Division
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Honeywell

First in Control

SINCE 1885

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Sales and Service offices in all principal cities of the world. Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan.

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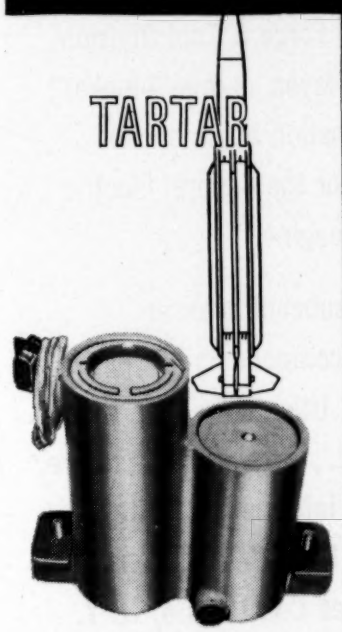
ADEL

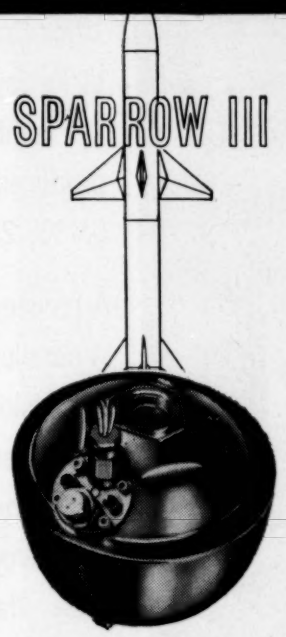
NEW

TARTAR



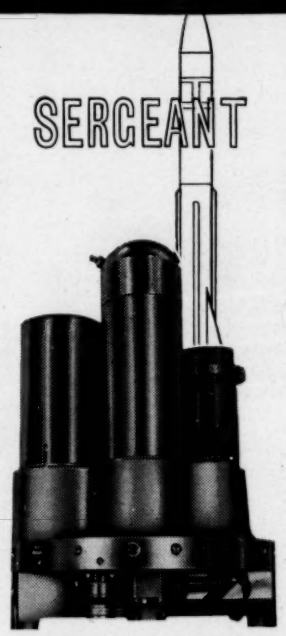
ELECTRIC MOTOR-DRIVEN HYDRAULIC POWER PACKAGE
0.2 GPM @ 865 PSI
0.49 GPM @ 715 PSI
Integrated power package incorporates reservoir, motor-driven gear pump and valves.

SPARROW III



3 YEAR STORAGE CAPABILITY
8100 PSI helium pressure, 127 cubic inch oil capacity, 2750 PSI operating pressure in 200 milliseconds, weight 20.5 lbs. max.

SERGEANT

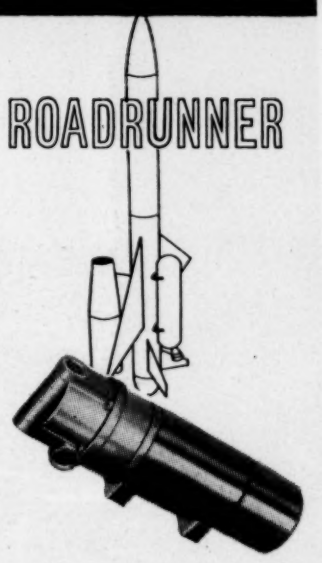


INTEGRATED PACKAGE
Incorporates electric motor, hydraulic pump, accumulator, reservoir and valves. 1 hour on and 1 hour off operation, 3450 PSI operating pressure, 3500 inch lbs. torque, actuation time 1.1 ± .10 seconds.

"CLASSIFIED"

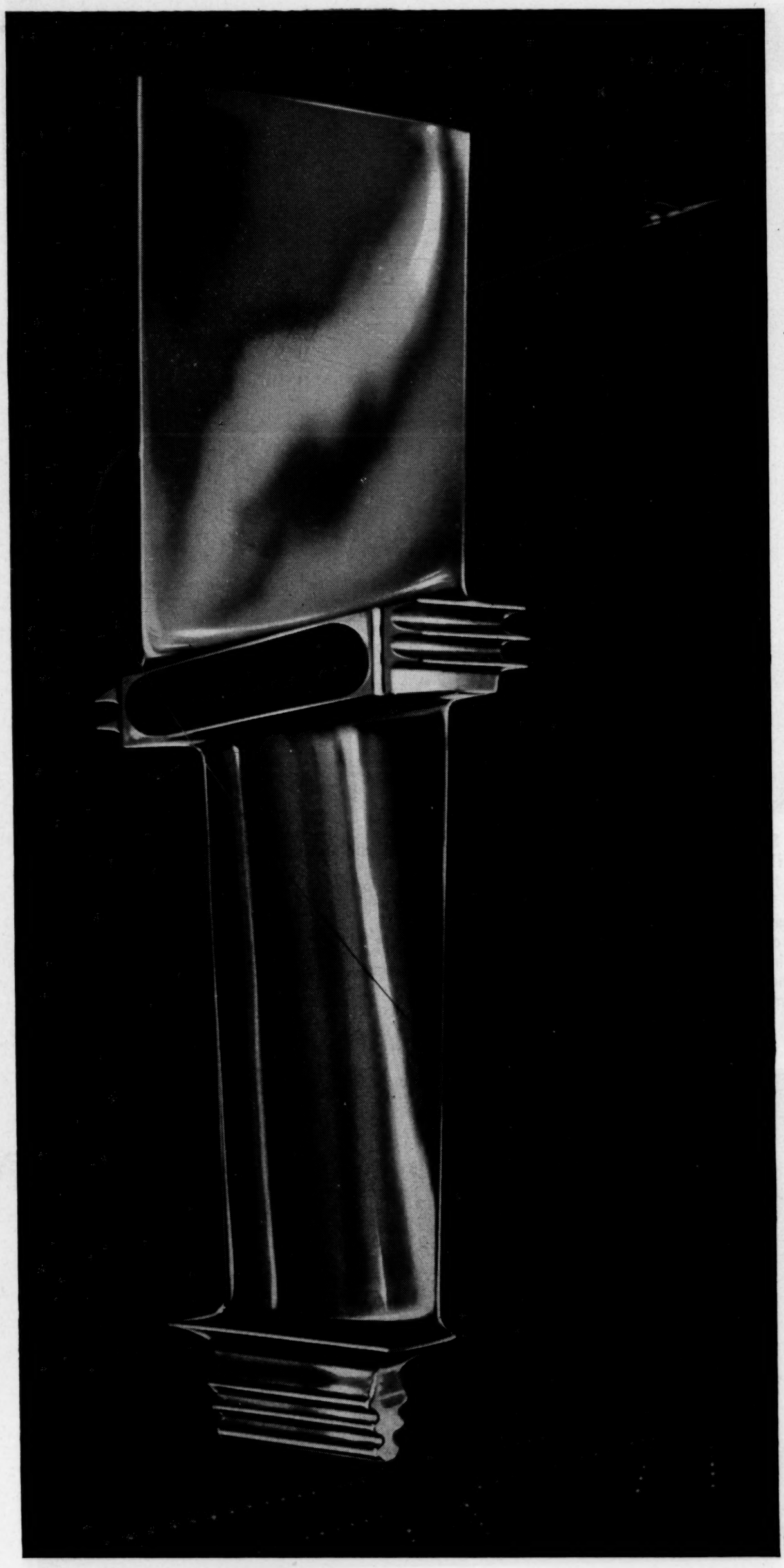
SOLENOID OPERATED HIGH PRESSURE POWER PACKAGE
800°F ambient temperature, 8000 PSI helium pressure, weight 6.5 lbs. max. 3 year storage capability.

ROADRUNNER



ELECTRIC MOTOR-DRIVEN GEAR PUMP
600 PSI, 4 GPM flow, 15 minutes on and 15 minutes off operation, weight 4.1 lbs. max.

ADEL



precision "blucket" for flight propulsion

UTICA® Typical of the blades, buckets, vanes and other jet engine components produced by Utica Drop Forge & Tool Division of Kelsey-Hayes, is this "blucket" —a combination blade-bucket produced for the General Electric CJ-805-23 engine.

A pioneer subcontractor in superalloy components for jet propulsion, Utica is in tune with the present . . . exploring the future. For further information, write Utica Drop Forge & Tool Division, Kelsey-Hayes Co., Utica 4, N. Y.

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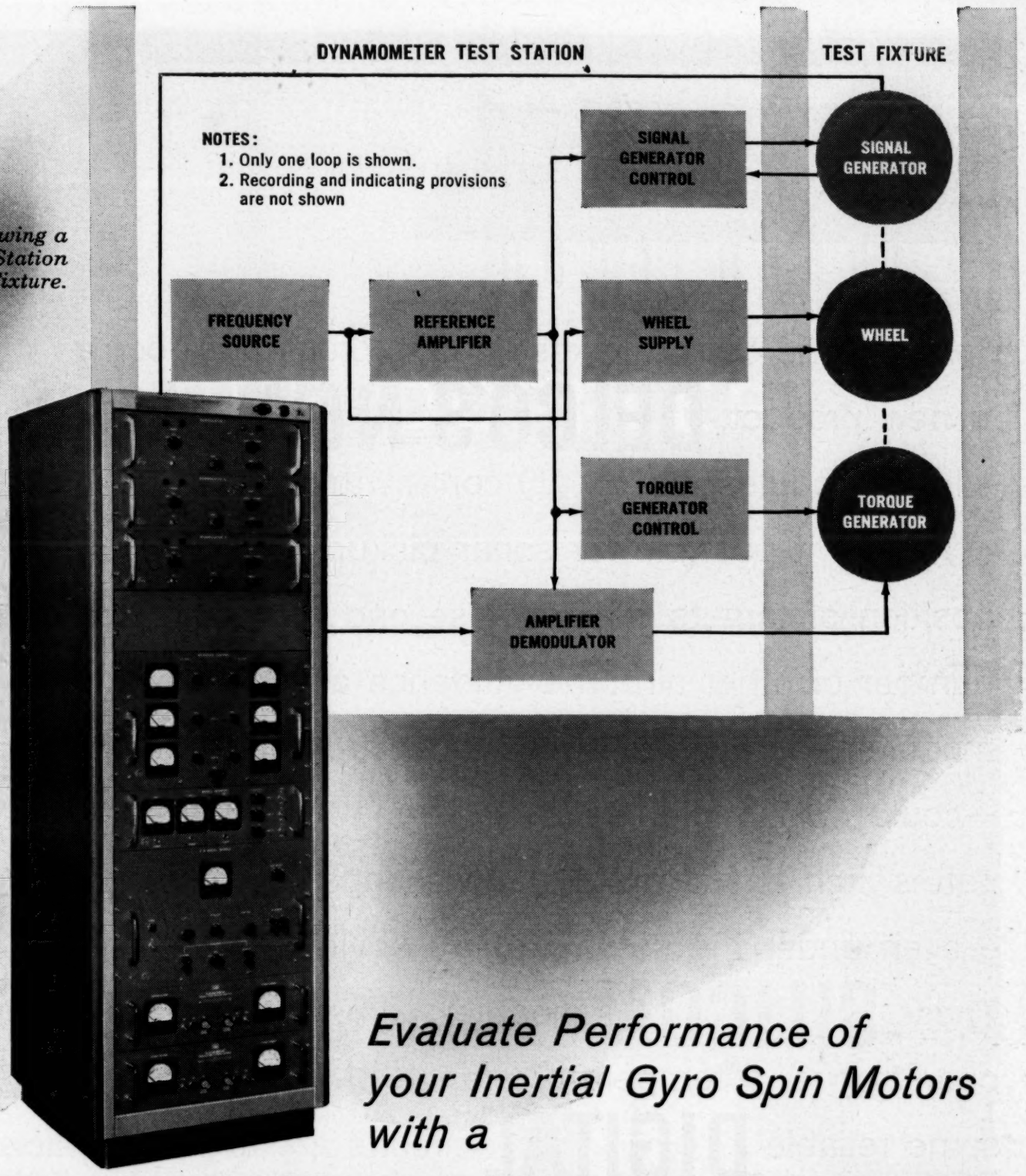


Typical system showing a Dunn Dynamometer Test Station with a Test Fixture.

Evaluate Performance of your Inertial Gyro Spin Motors with a

DUNN DYNAMOMETER TEST STATION

Now measure bearing torque of inertial gyro spin motors . . . with the new Dynamometer test station engineered by Dunn. The Dunn T1150 Dynamometer can be used for laboratory, development or production testing, as well as receiving inspection.

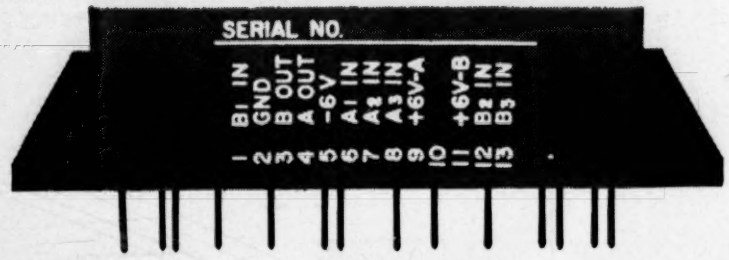
Designed and built originally for the M.I.T. Instrumentation Laboratory to test 25 IRIG wheels, the Dunn T1150 controls three test fixtures independently.

The gyro wheel is mounted in a single test fixture incorporating a signal generator and a torque generator. These microsyn transducers operate in a closed-loop, torque-nulling servo system. You get complete servo electronics . . . Dunn has incorporated provisions for visual and/or graphic recording of transducer signals.

Write for data sheet — Bulletin T1150.
Dunn Engineering Corporation,
225 O'Brien Highway, Cambridge 41, Mass.

DUNN ENGINEERING *CORPORATION*
CAMBRIDGE 41, MASSACHUSETTS

radar test systems • advanced electronic systems • inertial products • test facilities engineering



In less time than it takes light to cross this room, a new product, **DELCO'S NEW** high speed **10 MC** silicon modules, could: (1) correct the course of a missile in flight; (2) make it possible for sonar pickups to track and compute the position of targets with microsecond accuracy; and (3) handle any number of other airborne guidance and control functions that previous modules—due to low speed or environmental or performance limitations—could not handle. Delco Radio's 10mc modules, with a maximum gate-switch speed of 40 nanoseconds, convert data 100 times faster—even under the most extreme environmental conditions.

These **SILICON** modules come epoxy encapsulated, and operate over a temperature range of −55°C to +100°C. And these same reliable **DIGITAL** circuits are available packaged on plug-in circuit cards. These Delco **MODULES** are environmentally proved to: **SHOCK**, 1,000G's in all planes. **VIBRATION**, 15G's at 10 to 2,000 cps. **HUMIDITY**, 95% at max. temp. **STORAGE AND STERILIZATION TEMP.** −65°C to +125°C. **ACCELERATION**, 20G's. Designed for systems using from one module to 100,000, and the module's rated performance considers the problems of interconnection. Data sheets are available. Just write or call our Military Sales Department.

Physicists and electronics engineers: Join Delco Radio's search for new and better products through Solid State Physics.

PIONEERING ELECTRONIC PRODUCTS THROUGH SOLID STATE PHYSICS

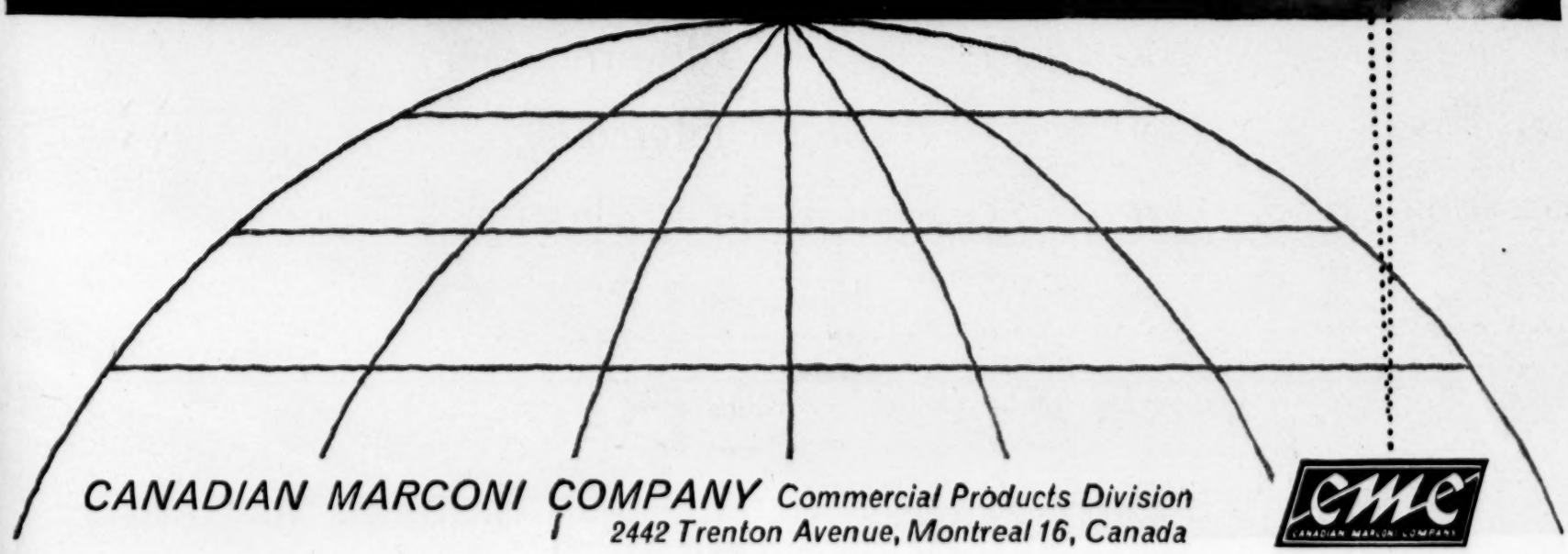
Division of General Motors • Kokomo, Indiana

DELCO RADIO
DEPENDABILITY
RELIABILITY

Circle Number 36 on Reader-Service Card

AIRBORNE DOPPLER

First aloft — and still ahead — CMC airborne Doppler sensors provide reliable, accurate navigational information — irrespective of time, terrain or weather. Carried wholly within the aircraft . . . entirely independent of ground-based aids . . . the CMA-620 series continues to show the way for the airlines of the world. Of *all* Doppler equipped international jets, by far the greater proportion uses the CANADIAN MARCONI COMPANY system.



CANADIAN MARCONI COMPANY ***Commercial Products Division***
2442 Trenton Avenue, Montreal 16, Canada

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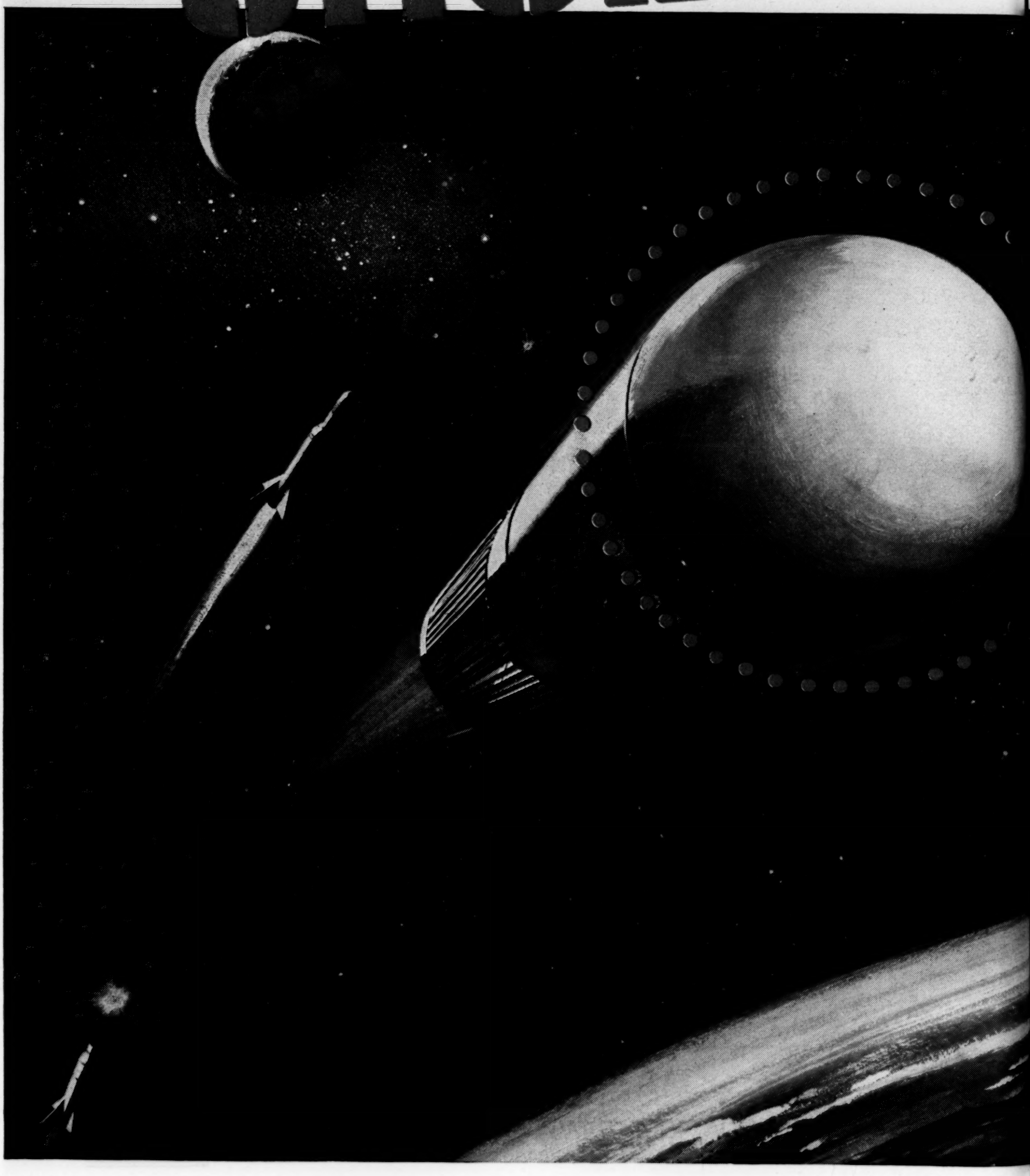
URGENT:



STOP THAT MISSILE - AND THE NEXT ONE TOO!

In probing uncharted areas of electronics to solve the critical anti-missile problem, our scientists and engineers have developed advanced early warning systems of vital significance to national security.

For example, our work on ballistic missile defense systems has led to the development of a unique method for performing a great many dissimilar radar functions simultaneously and from one antenna. This technique —known as multifunction phased array radar—allows one advanced radar to replace many conventional radars. It permits long-range detection and selective tracking and targeting of numbers of small high-speed objects, including satellites, other space vehicles, missiles and warheads.

Since tracking beams can be positioned in a *fraction of a microsecond,* it is possible to track a great many targets while continuously searching for additional missile threats. And because phased array radar beams are electronically steered, the antennas do not rotate; and there is no chance for mechanical failure.

Major advances such as phased array radar are typical of the work being done by the scientists and engineers of the entire General Telephone & Electronics corporate family. The vast communications and electronics capabilities of GT&E, directed through Sylvania Electronic Systems, can research, design, produce, install and service complete systems. These include the entire range from detection and tracking, electronic warfare, intelligence and reconnaissance through communications, data processing and display.

That is why we say—the many worlds of defense electronics meet at Sylvania Electronic Systems, division of Sylvania Electric Products Inc., 40 Sylvan Road, Waltham 54, Massachusetts.

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Including: Automatic Electric • Electronic Secretary Industries • General Telephone & Electronics International General Telephone & Electronics Laboratories • Leich Electric • Lenkurt Electric • Sylvania Electric Products

Fifth engine tests Boeing 727 design feature

The Boeing 707 prototype, which proved out advanced design features of the Boeing 707 and 720 jetliners, is now at work as a flying test bed for the next generation of Boeing jets—the three-engine short-range 727.

The prototype is shown above equipped with a fifth engine, conducting exhaustive tests of the efficiency and performance of side-mounted engines, a feature of the 727. In addition, the 707 prototype is testing new high-lift wing flaps, aircraft systems and other design features that will make the 727 the most advanced jetliner of its class.

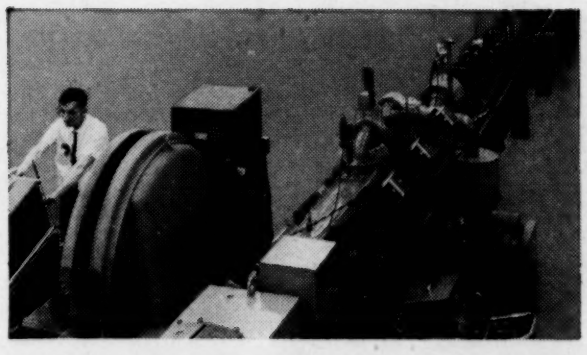
Already, one hundred seventeen 727s have been ordered by American Airlines, Eastern Air Lines, Lufthansa German Airlines and United Air Lines. Deliveries begin in 1963. The 727 will operate from 5,000-foot runways with full payload, serving routes from 150 to 1700 miles. It offers airlines many advantages, including components and systems that have demonstrated outstanding performance and reliability in over 300,000,000 miles of Boeing jetliner operations.

BOEING

GM's DSD tracks down the answer!

In the unique Flight Physics Laboratory of General Motors Defense Systems Division, studies are now in progress on hyper-velocity projectiles. Projectiles travel as fast as 31,000 feet per second through DSD's light gas gun. It is expected that speeds up to 40,000 feet per second will soon be attained. These studies provide clues to new missile detection methods and instruments which will identify the distinctive signatures of missiles and meteors. They will prove in seconds which they are and where they come from.

Scientific areas now under study: Aero-Space • Sea Operations • Land Operations • Biological Systems • Technical Specialties



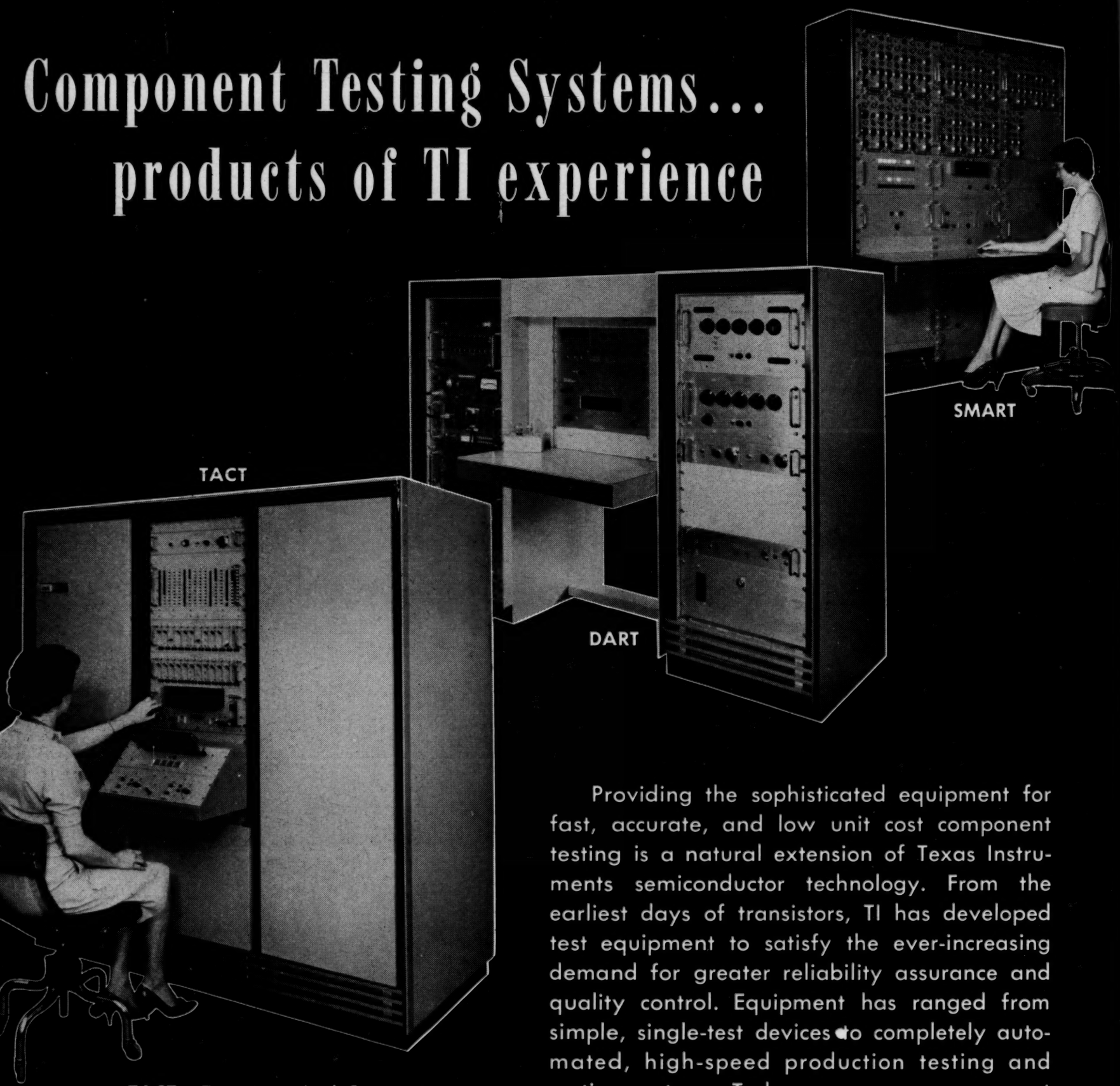
Two Light Gas Guns permit flight of hyper-velocity projectiles . . . including studies of high-speed impact, properties of ionized gases, new methods of detection and identification. If you can use facilities like these, contact DSD.

GENERAL MOTORS

DEFENSE SYSTEMS DIVISION

DEFENSE SYSTEMS DIVISION OF GENERAL MOTORS CORPORATION • WARREN, MICHIGAN AND SANTA BARBARA, CALIFORNIA

Component Testing Systems... products of TI experience



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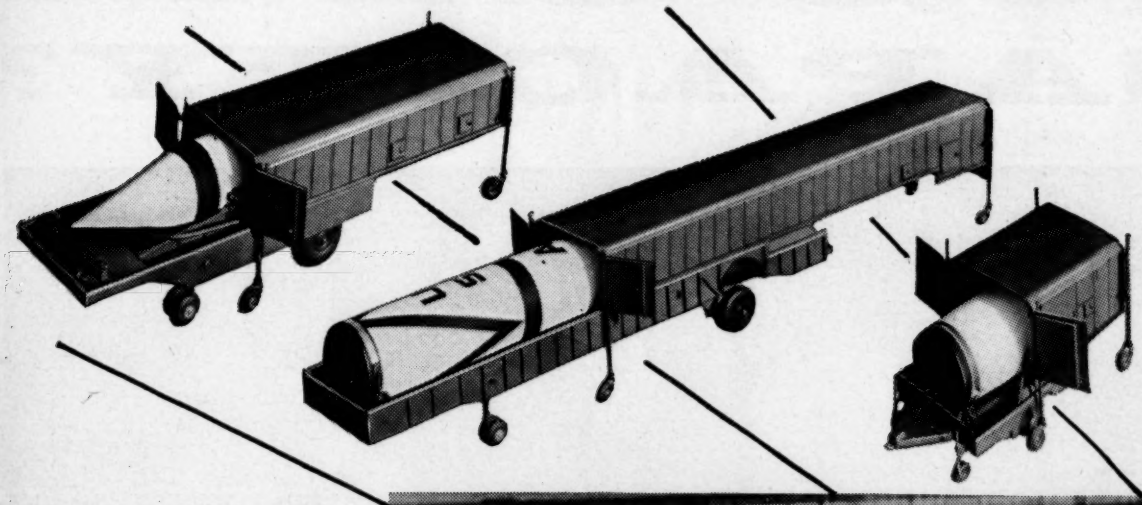

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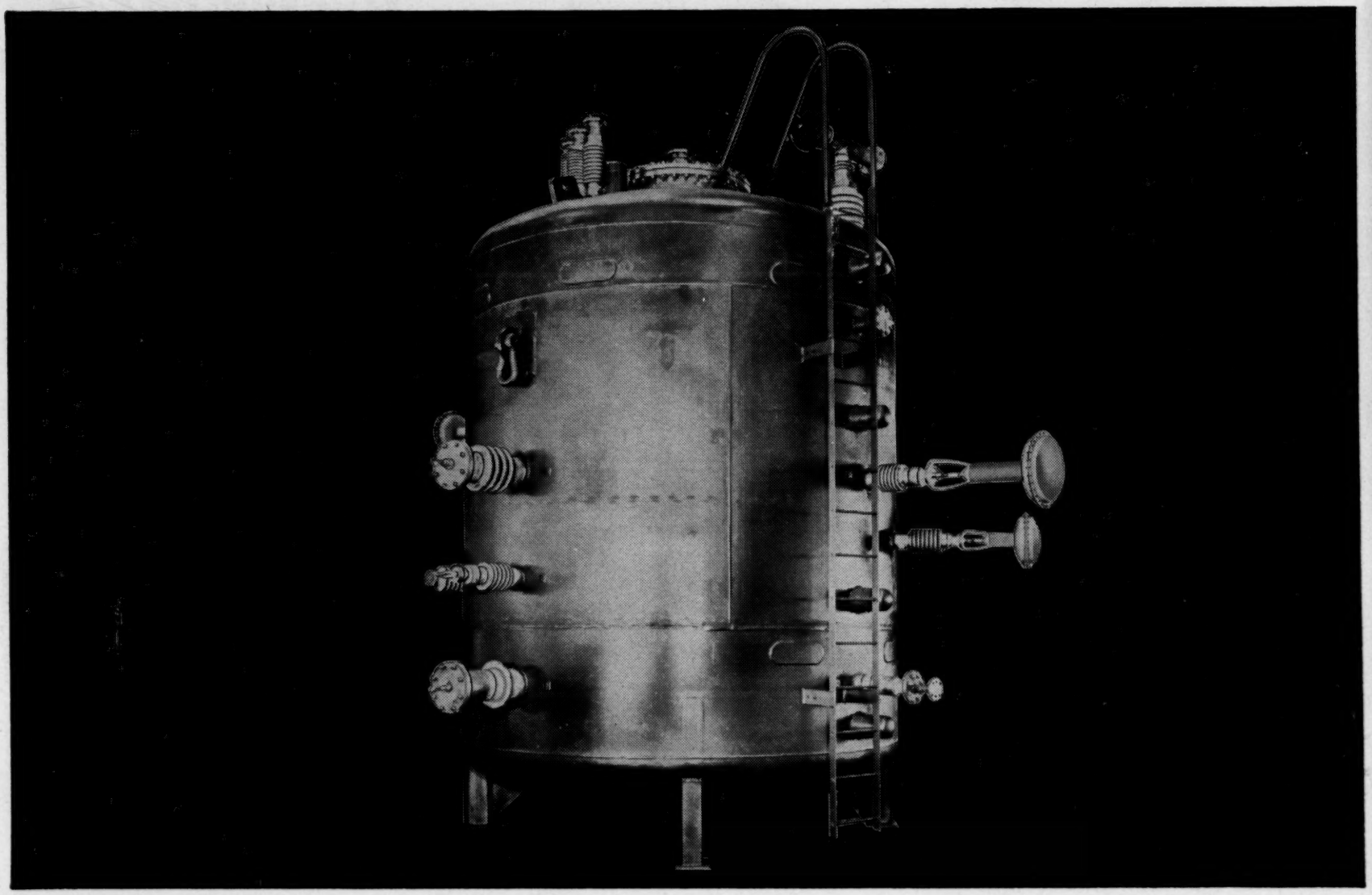

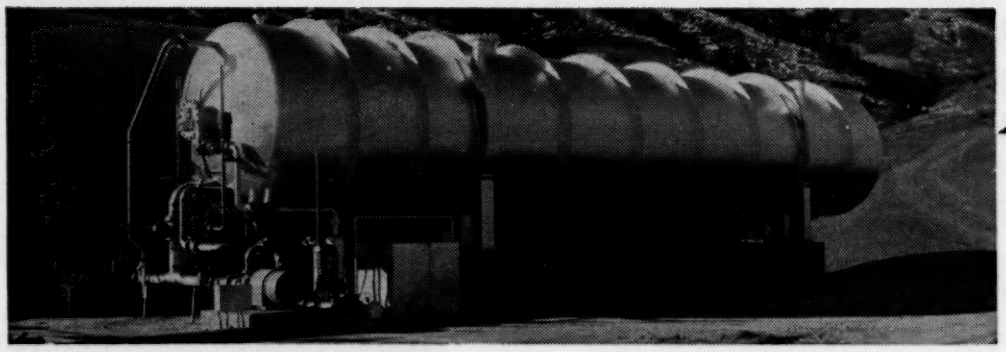

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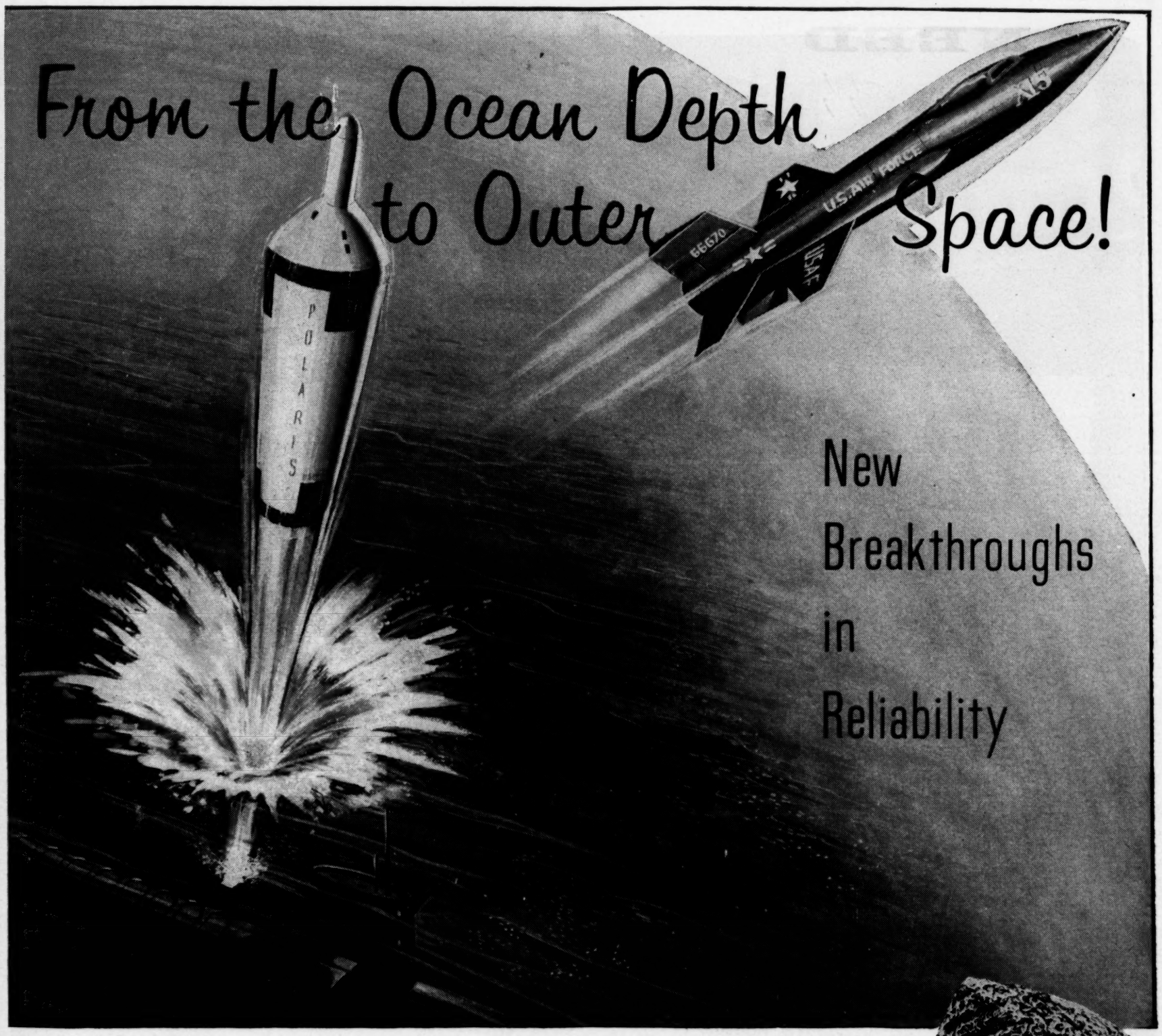

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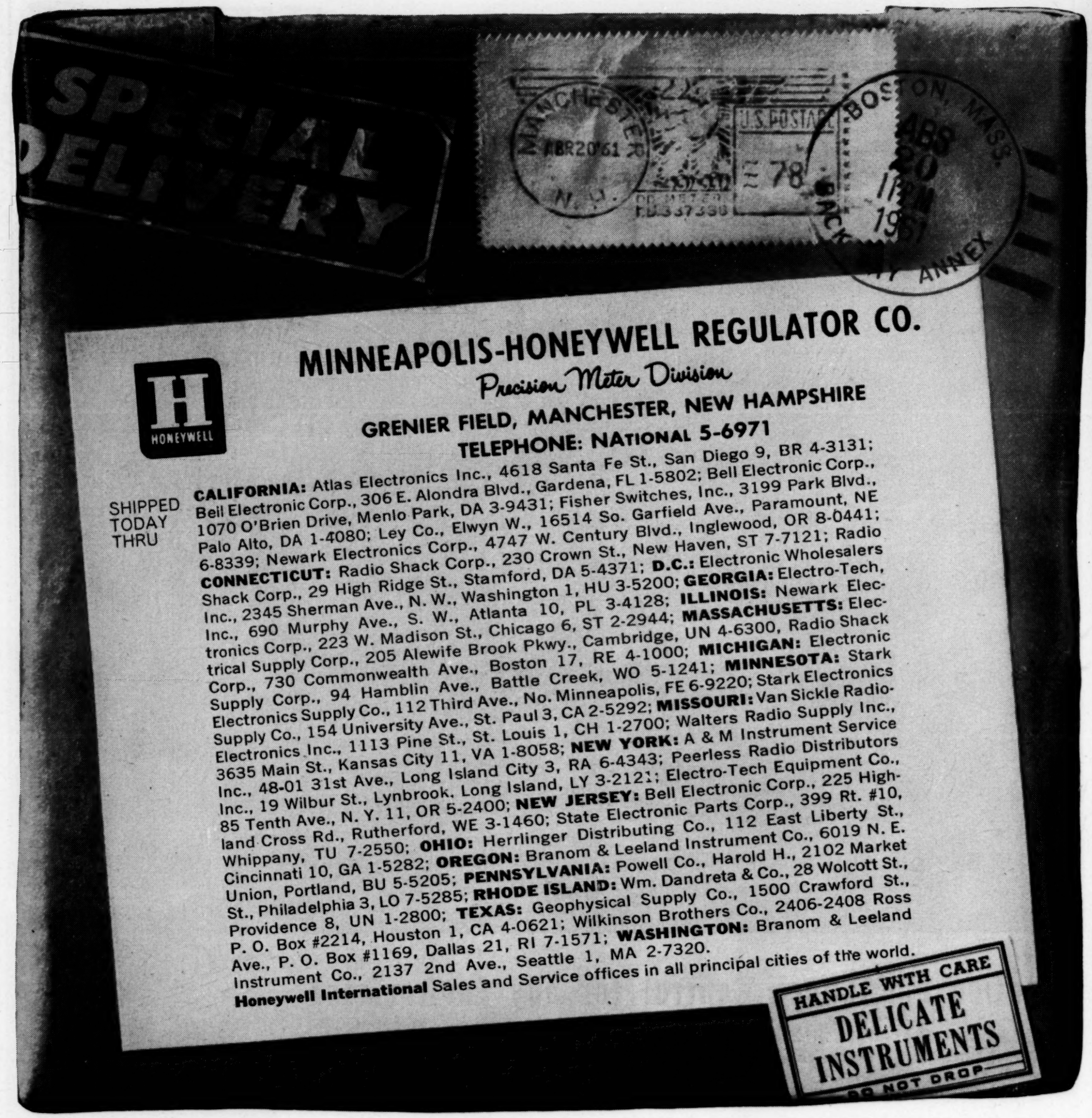

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Choice of the name ASTRODATA reflects the branch of space age technology in which our people are well recognized—data control systems and ancillary instrumentation. ASTRODATA systems include a complete timing system on the Pacific Missile Range, operational checkout system for the Atlas missile at both Vandenberg AFB and Cape Canaveral, a high-speed, high-accuracy, data handling system for Bell Labs for use in conjunction with Nike Zeus tests at New Mexico's White Sands Missile Range, an automatic digital temperature recording system for monitoring temperatures within an atomic reactor, and a high-speed digital acquisition and processing system which speeds space probes at Lockheed's Missile and Space Division. Standard products include a wide range of time code generating, translating and tape searching equipment, dual mode amplifiers for low-level commutation and a variety of solid-state, plug-in modules.

Significantly, ASTRODATA now offers nationwide sales and service. For more information concerning the talent and capabilities of our company, write for a copy of *"This is Astrodata..."* to Astrodata, Inc., 240 E. Palais Road, Anaheim, California.

ASTRODATA INC.

Successors to Epsco-West

ANAHEIM, CALIFORNIA

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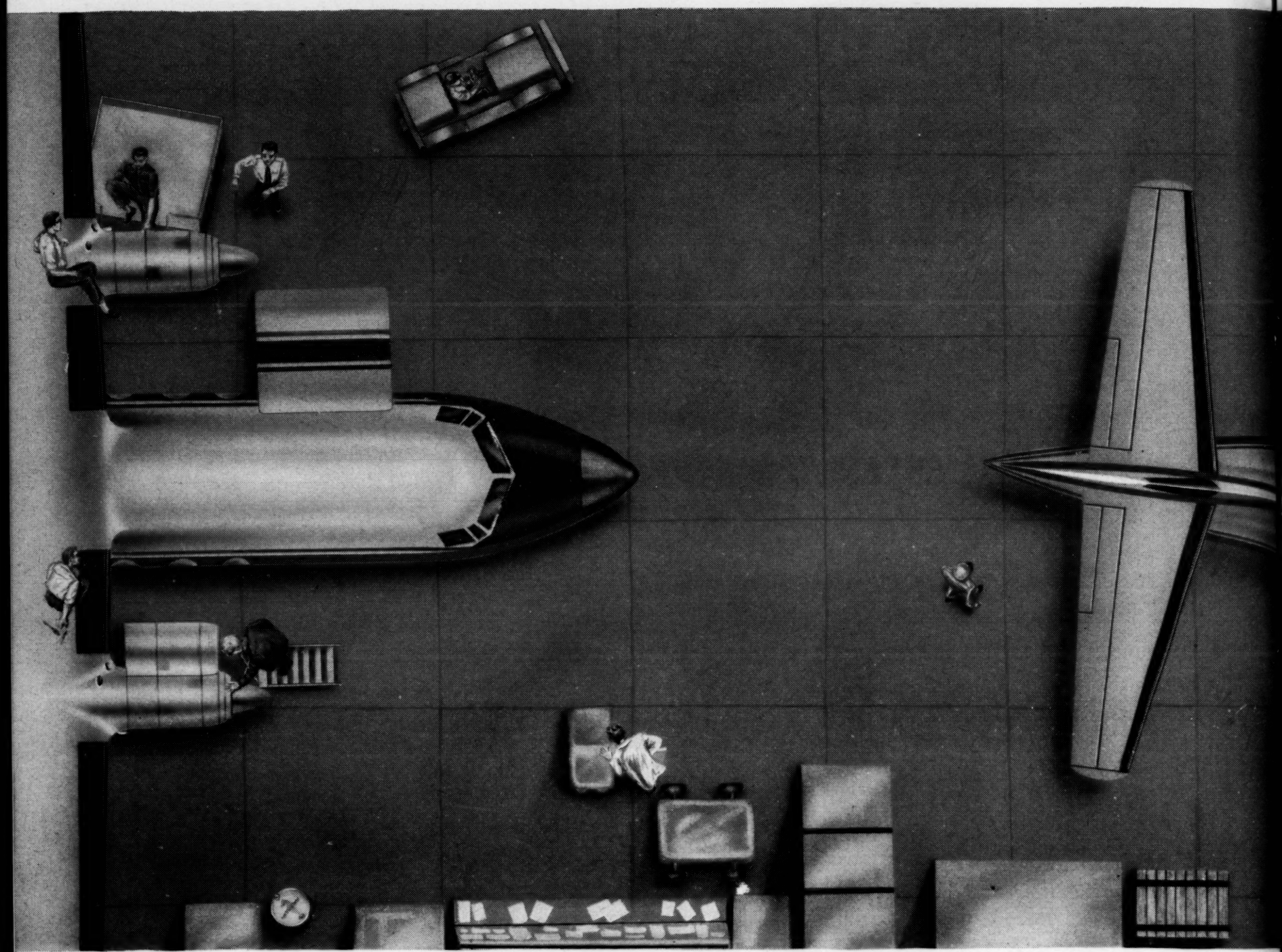

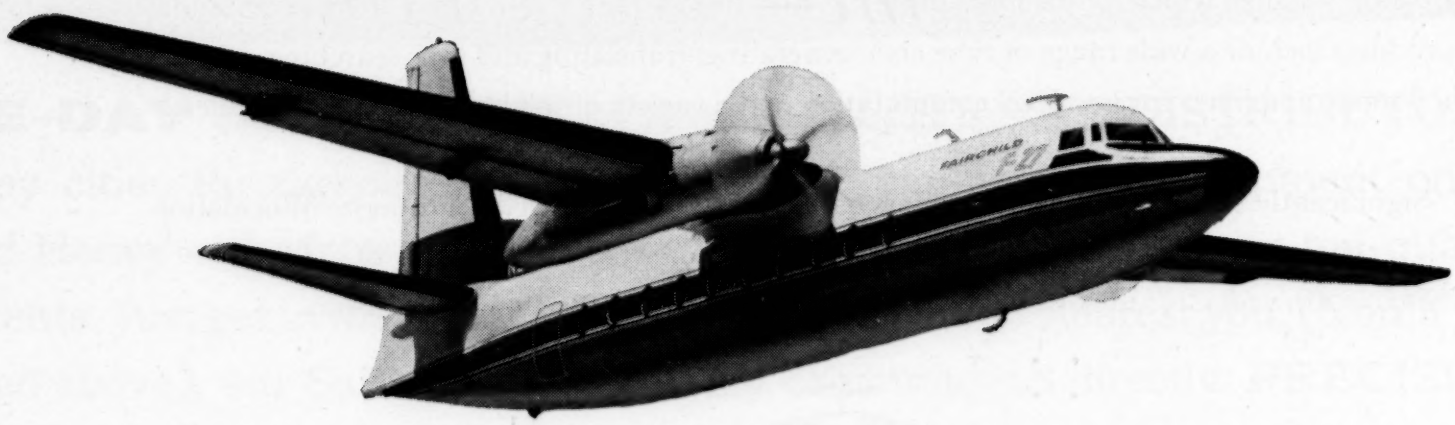

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transcontinental range
2800 miles, long range cruise

NEW
higher gross weight
increased to 39,400 lbs.

NEW
fuel capacity
1920 gallons

NEW
air conditioning
higher circulating flow

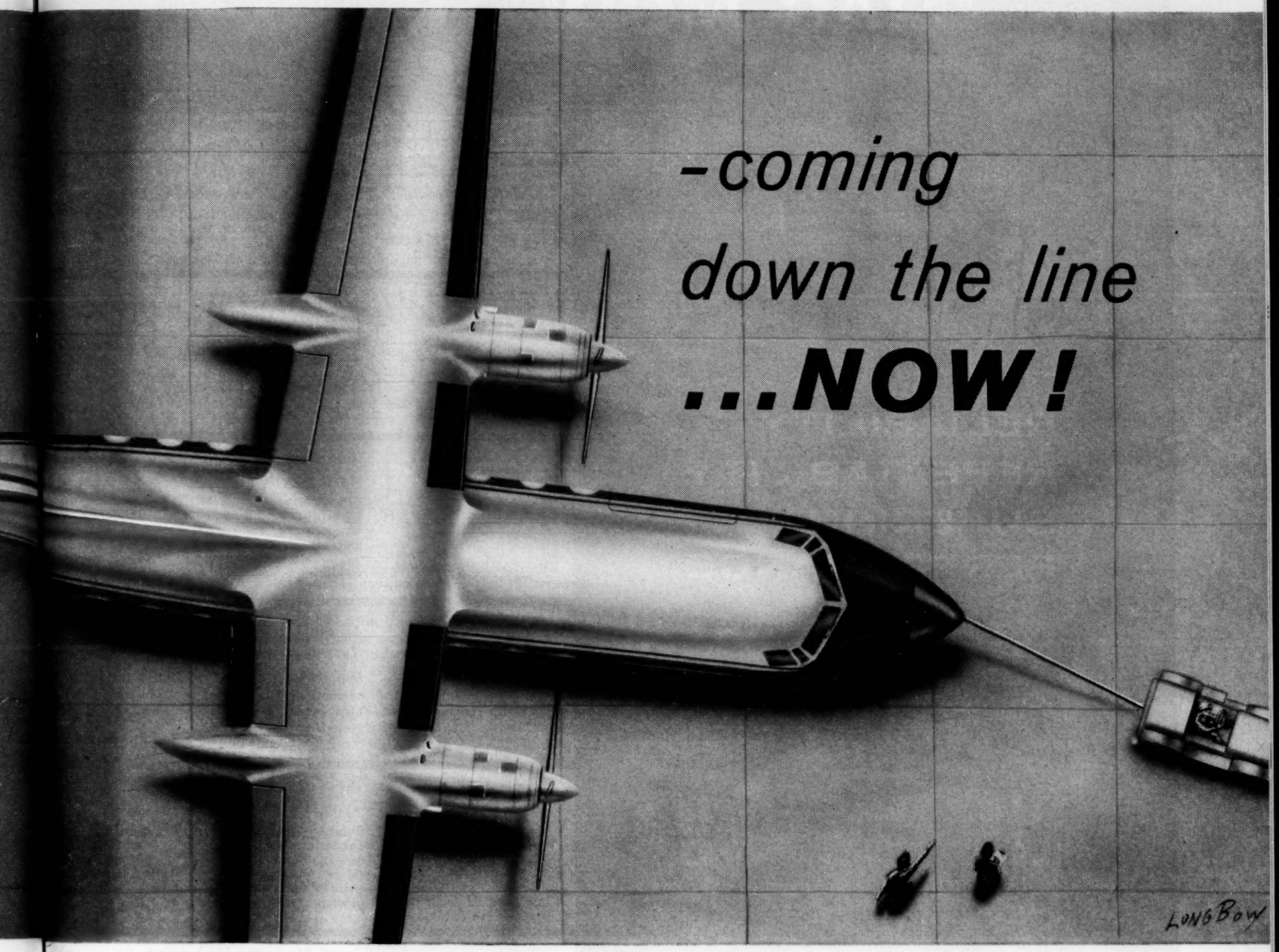
NEW
improved pressurization
higher cruise altitude

NEW
landing weight
increased to 37,500 lbs.

NEW
ground handling
improved nose steering

NEW
greater cargo capacity
increased payload

F-27 "F" *Propjet*



higher gross weight—transcontinental range

Fairchild's new "F" carries more, flies higher, goes farther—gets there faster. Unmatched in the medium transport field, the F-27 has been made even better by the progressive engineering improvements incorporated in the "F". It has no equal for utility and economy.

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Modern—Newest in its category, the F-27 is designed specifically for turbine power. With its truck bed height floor, it's easy to load.

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Rugged and safe—Over 50 million plane miles have been logged. Airline operators alone make an F-27 landing or take-off every two minutes—around the clock. The "high time" F-27 has already flown over 7500 hours. Six have flown over 6000 hours each and another six over 5000 hours.

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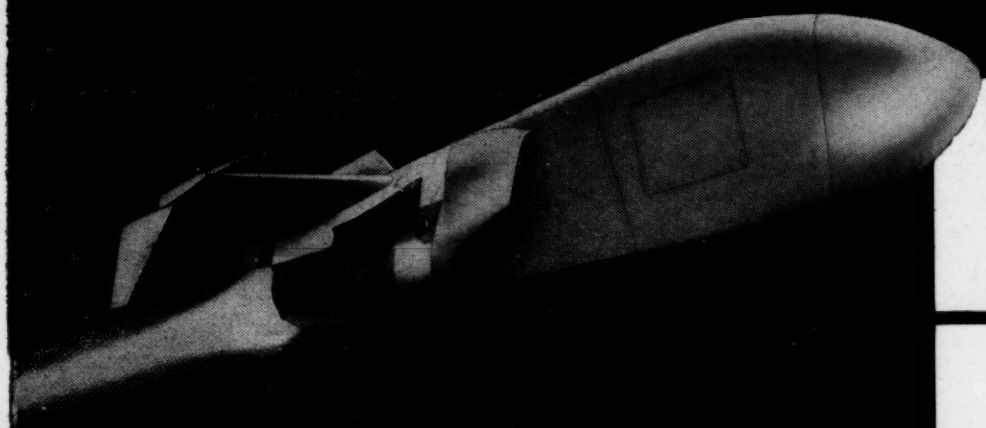

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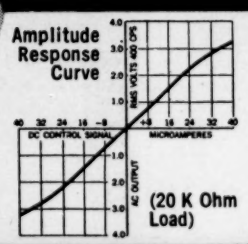
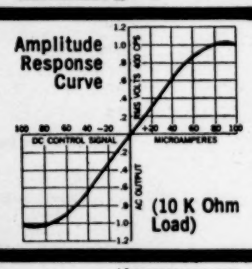


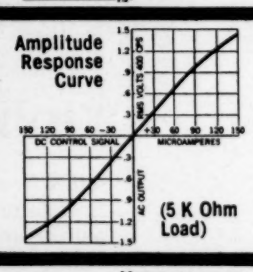
Input Magnetic Modulator
Type No. IMM 487-4

Subminiature "MAG MOD"® featuring high input signal sensitivity and high AC output impedance. Male or female mounting.



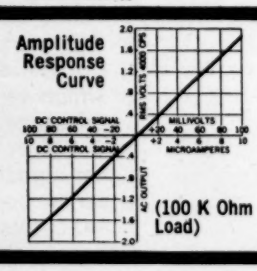
Input Magnetic Modulator
Type No. IMM 495-8

Subminiature "MAG MOD"® featuring wide band width, multiple signal input circuits, extreme zero stability from −65°C to +135°C, low null amplitude or noise level. Mounting available male or female.



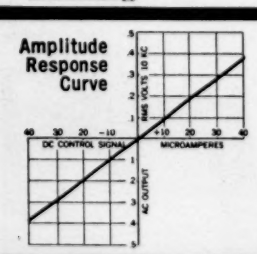
Input Magnetic Modulator
Type No. IMM 504-5

Subminiature "MAG MOD"® featuring low input and output impedance, resistance vs. temperature compensated input, extreme zero stability, repeatability and insignificant hysteresis. Supplied with male or female mounting.



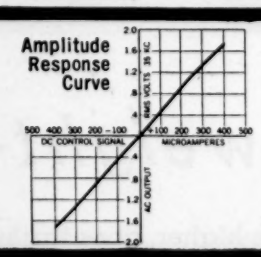
Input Magnetic Modulator
Type No. IMM 562-1

Subminiature "MAG MOD"® featuring 4 KC carrier operation, wide frequency band width, high output impedance and voltage range. Mounting male or female.



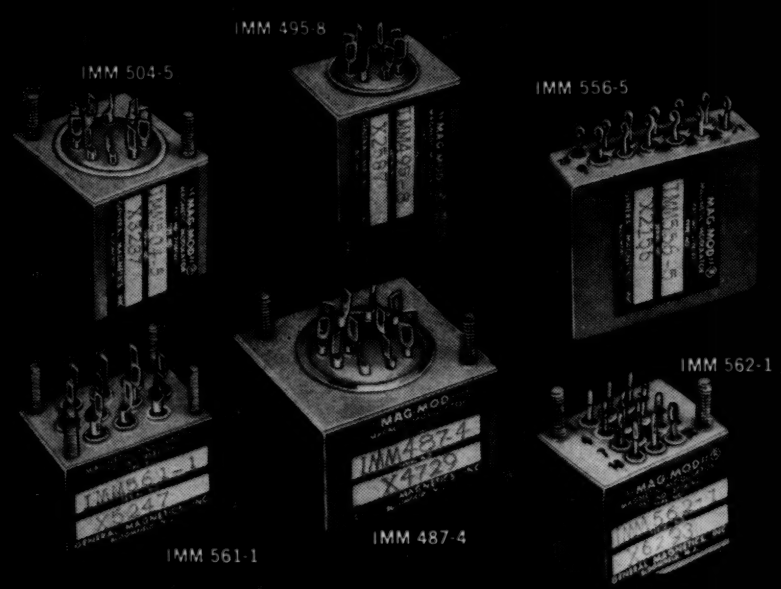
Input Magnetic Modulator
Type No. IMM 561-1

Subminiature "MAG MOD"® featuring low carrier energy level operation, very wide frequency band width, wide output operating range, minimum size and weight. Mounting male or female. May be mounted directly on printed circuit boards.



Input Magnetic Modulator
Type No. IMM 556-5

Subminiature "MAG MOD"® featuring high frequency carrier operation (35 KC), flat construction for printed circuit mounting, low output impedance and clean output fundamental frequency wave form. Mounting supplied male or female.



Designed for Subminiature
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New miniature designs of these reliable "MAG MODS"® make them ideal for incorporation into transistorized printed circuit assemblies. There is no sacrifice of dynamic response. They offer the engineer/designer the solution to problems involved in a wide range of data systems where analog circuit operations are encountered. To insure complete flexibility, the mechanical mounting on any "MAG MOD" may be modified to conform to your particular packaging requirements.

- **1% repeatability throughout entire service life**
- **Negligible hysteresis**
- **Faster response time**
- **Extreme stability over a wide temperature range**
- **Infinite service life**
- **Extremely lightweight— compact design**

GENERAL MAGNETICS • INC

FOR RELIABILITY...

MAGNETIC MODULATORS

TYPE NUMBER	IMM 487-4	IMM 495-8	IMM 504-5	IMM 562-1	IMM 561-1	IMM 556-5
Excitation Carrier Voltage and Frequency	115 V @ 400 cps	115 V @ 400 cps	115 V @ 400 cps	2.5 V RMS @ 4 KC	1.0 V RMS @ 10 KC	6 to 10 V RMS @ 35 KC
Control Signal Winding DC Resistance	Winding No. 1 6200 ohms Winding No. 2 7400 ohms	Signal Winding No. 1 550 ohms Signal Winding No. 2 600 ohms	1000 ohms	Signal Winding 1300 ohms Feedback Winding 160 ohms	200 ohms	5000 ohms
Input Control Signal Range	0 to ±40 μa Each Winding	0 to ±100 μa (Both Sig. Windings in Series)	0 to ±100 μa	0 to ± 100 μa 0 to ± 1 V Bipolar	0 to ±400 μa	0 to ±400 μa
Amplitude Modulated AC Output Range	3 V RMS @ 400 cps Phase Reversing	0 to 1 V RMS @ 400 cps Phase Reversing	0 to 1.5 V RMS @ 400 cps Phase Reversing	0 to 6 V RMS @ 4000 cps Phase Reversing	0 to 3 V RMS @ 4 KC Phase Reversing	0 to 1.8 V RMS @ 35 KC Phase Reversing
Differential Gain RMS mv AC Out/μa Signal In	100 mv/μa	15 mv/μa	10 mv/μa	200 mv/μa	10 mv/μa	4.2 mv/μa
Null Amplitude (Noise Level) mv RMS	25 mv RMS Maximum	5 mv RMS Maximum	10 mv RMS Maximum	30 mv RMS Maximum	10 mv RMS Maximum	20 mv RMS Maximum
Output Impedance	Approx. 30 K ohms	1600 ohms	1000 ohms	Approx. 70 K ohms	Approx. 40 K ohms	900 ohms Each Output Wind.
External Load (Suggested)	Approx. 20 K ohms	Approx. 10 K ohms	Approx. 5 K ohms	Approx. 100 K ohms	Approx. 100 K ohms	1000 ohms Each Output Wind.
Null Drift (In terms of Input Signal) −65°C to +135°C	Less than ±0.25 μa Over Temp. Range	Less than ±0.25 μa Over Temp. Range	±1 μa Maximum Over Temp. Range	±0.5 μa Maximum Over Temp. Range	±1 μa Over Temp. Range	±2 μa Over Temp. Range
Hysteresis (% of Input Control Signal)	0.5% Maximum	0.5% Maximum	0.5% Maximum	Approx. 0.5%	0.5% Maximum	0.5% Maximum
% Harmonic Distortion in Output AC Modulated Envelope	Approx. 40% (3rd Harmonic)	Approx. 25% (3rd Harmonic)	Approx. 30% (3rd Harmonic)	Approx. 15% (3rd Harmonic)	Less Than 10% (3rd Harmonic)	Approx. 5% (3rd Harmonic)
Overall Dimensions (in Inches)	1¼ x 1⅛ x ¾	¾ x 1 x 1	1 x 1 x 1	1 x 11/16 x ⅞	11/16 x 1 x ⅝	7/16 x 1⅜ x 1¼
Type of Mounting	4-40 Studs or Inserts	4-40 Studs or Inserts	4-40 Studs or Inserts	4-40 Studs or Inserts	2-56 Studs	4-40 Tapped Holes or Studs
Weight in Ounces	Approx. 1.25	Approx. 1	Approx. 1.1	0.75	0.6	1
Response Time (Band Width cps)	0.01 sec. for 15 K Sig. Source Imp. (12 cps Corner Frequency)	20 cps for 10 K Sig. Source Imp. 25 cps for 20 K Sig. Source Imp. (Both Sig. Windings in Series)	5 cps for 1 K Sig. Source Imp. 10 cps for 5 K Sig. Source Imp. 20 cps for 10 K Sig. Source Imp.	70 cps for 10 K Sig. Source Imp. (Time Constant Approx. 2 Milli-Seconds)	Corner Frequency 2 KC for Sig. Source Imp. of Approx. 6 K ohms	Corner Frequency 200 cps for 600 ohm Signal Source Imp. or 1000 cps for 5 K Source

Magnetic Multiplying Modulator Model MCM 515-1

Actual Size

The MAGNETIC MULTIPLIER is a miniaturized magnetic modulator specifically designed to deliver an analog output voltage which is the continuous product of two variable input voltages. One of these is an excitation voltage which varies over a pre-determined range; in this case, 0 to 1 VRMS 400 cycles per second. The other signal is a DC current which varies between 0 and ±400 μa. The output voltage is 400 cycles AC, and is always in phase or 180° out of phase with the variable excitation or fixed reference, i.e., in phase when the variable amplitude DC signal is positive, and 180° out of phase when the DC signal is negative. The general schematic is illustrated in Fig. 1. The relationship between variable alternating supply signal voltage E_S, variable direct current control signal E_C, and the alternating load voltage E_L having a sinusoidal wave shape is denoted by the equation—

E_L = Constant × E_S × E_C.

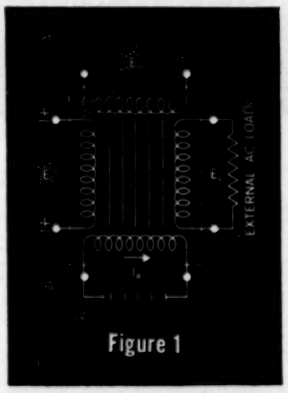


Figure 1

This expression, which defines the fundamental principle of the four quadrant MAGNETIC MULTIPLYING MODULATOR, can be clearly illustrated by linear transfer response curve families as shown at right, in Figure 2-A and Figure 2-B.

Illustrating:

(1) Load voltage E_L as a function of alternating supply signal voltage E_S with control DC signal voltage E_C as a parameter.

(2) Load voltage E_L as a function of control DC signal voltage E_C with alternating supply voltage, E_S as a parameter.

With linearity response curves held to within approximately 1 to 2% of theoretical straight lines, the product accuracy of the fundamental equation will be within 2 to 5% of the theoretical product.

SPECIFICATIONS MODEL MCM 515-1

Variable Excitation Carrier Voltage and Frequency	Variable AC Signal 0 to 1 V RMS 400 cps
Control Signal Winding DC Resistance	DC Signal Winding Resistance 2650 ohms
Input Control Signal Range	Variable DC Signal 0 to ±400 μa
Amplitude Modulated AC Output Range	0 to 0.9 V RMS @ 400 cps Phase Reversing
Null Amplitude (Noise Level) mv RMS at Max. AC Excitation	5 mv RMS
Output Impedance	Approx. 3500 ohms
External Load (Suggested)	Approx. 25 K ohms
Null Drift (In terms of Input Signal) −65°C to +135°C	±2 μa over Temperature Range
Hysteresis (% of Input Control Signal)	0.5% Maximum
% Harmonic Distortion in Output AC Modulated Envelope	Less than 5%
Overall Dimensions (In Inches)	27/32 x 27/32 x 1 3/16
Type of Mounting	4-40 Insert or Stud
Weight	Approx. 1 Ounce

Amplitude Response Curve

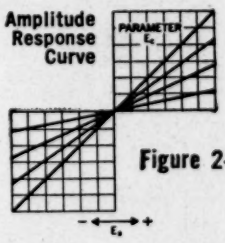


Figure 2-A

Amplitude Response Curve

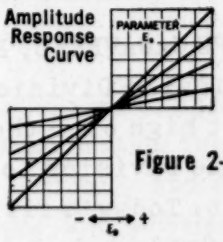
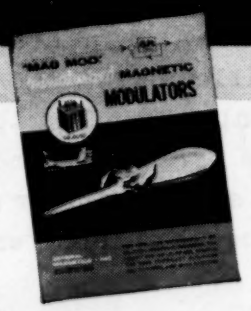


Figure 2-B

Typical "Mag Mod" Circuit Applications—

Include algebraic addition, subtraction, multiplying, raising to a power, controlling amplifier gain, mechanical chopper replacement in DC to fundamental frequency conversion, filtering and low signal level amplification.

Consult General Magnetics for magnetic amplifier components of proven reliability. These dependable instruments are widely employed in automatic flight systems, fire control, analog computers, guided missiles, nuclear equipment, antennas, gun turrets, commercial power amplifiers and complete control systems. Miniature, subminiature, standard and customized types available.



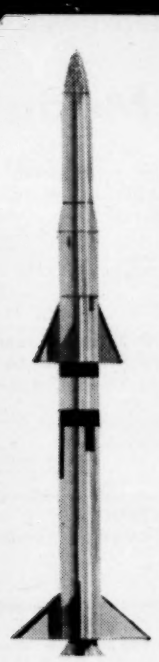
Call or write for new Brochure 102 on "MAG MOD" Miniaturized Magnetic Modulators and Magnetic Multiplying Modulators. Please address inquiries on company letterhead.

135 BLOOMFIELD AVE., BLOOMFIELD, NEW JERSEY

GM INC.

Circle Number 51 on Reader-Service Card

6 5 4 3 2 1



AIR FORCE
BLUE SCOUT
SIX
SUCCESSIVE FIRINGS—
FOUR
SUCCESSFUL FLIGHTS

[1] CAPE CANAVERAL, Fla., Sept. 21, 1960--United States Air Force Officers and Airmen of the Air Force Ballistic Missile Division (ARDC) today successfully launched a four stage solid fuel Blue Scout Junior research rocket high over the Atlantic Missile Range. [2] CAPE CANAVERAL, Fla., Nov. 8, 1960--The Air Force Ballistic Missile Division today test launched for the second time a four stage, solid fuel, Blue Scout Junior research rocket. Today's firing is part of the Air Force program to launch vitally needed scientific space packages on a regularly scheduled basis. [3] CAPE CANAVERAL, Fla., Jan. 7, 1961--The Air Force today launched the largest solid fueled Ballistic vehicle to date at the Atlantic Missile Range. Carried for the first time aboard the Blue Scout test vehicle was a guidance system operative during all three stages. [4] CAPE CANAVERAL, Fla., Mar. 3, 1961--An Air Force Blue Scout rocket today lofted a 172 pound payload approximately 1,580 statute miles into space. The payload was designed to make detailed radiation measurements as it travelled through the lower edges of the Van Allen Belt. [5] CAPE CANAVERAL, Fla., April 12, 1961--Development Flight No. 5 of the Blue Scout was successfully launched today, the Air Force announced. Carrying seven experiments, three bursts of seven flares were fired and tracked by a camera system from Cape Canaveral. [6] CAPE CANAVERAL, Fla., May 10, 1961--A range safety officer made a $500,000 decision yesterday and ordered destruction of a Blue Scout Junior rocket seconds after it was launched. Yesterday's failure was only the second for the Blue Scout in six firings.

The reliability of the Air Force Blue Scout is one of the highest in the industry. Aeronutronic is system engineer, payload and test contractor on Blue Scout. Additional information is available upon request.

Ford AERONUTRONIC
AERONUTRONIC DIVISION Ford Motor Company, DEFENSE PRODUCTS GROUP
NEWPORT BEACH, CALIFORNIA

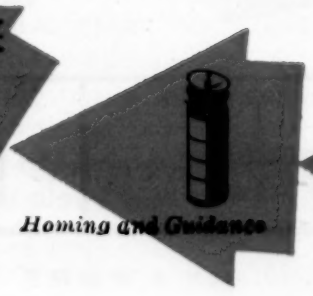
Circle Number 52 on Reader-Service Card

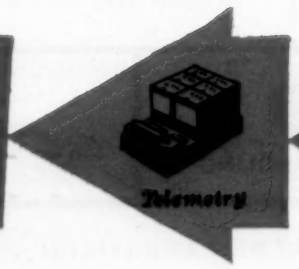
filling in the blank space...

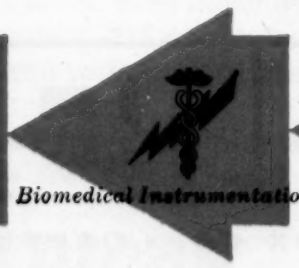
Bendix-Pacific Systems and Components – in so many fields – are playing a vital role in helping to push back the frontiers of space. Bendix-Pacific reaction controllers, for example, provide stabilization for space vehicles; electro-mechanical actuator systems control the canard fins on missiles. Telemetry and display equipment developed by Bendix-Pacific rings the world to monitor the functions and physiological reactions of the astronaut. Other Bendix-Pacific developments are ready now to trigger a soft landing on the moon or to provide a proven system for long range acquisition and station keeping. Bendix-Pacific offers all of these advanced capabilities to assist you in your space project. Phone or wire us today.

Bendix-Pacific Division
NORTH HOLLYWOOD, CALIFORNIA

THE Bendix CORPORATION







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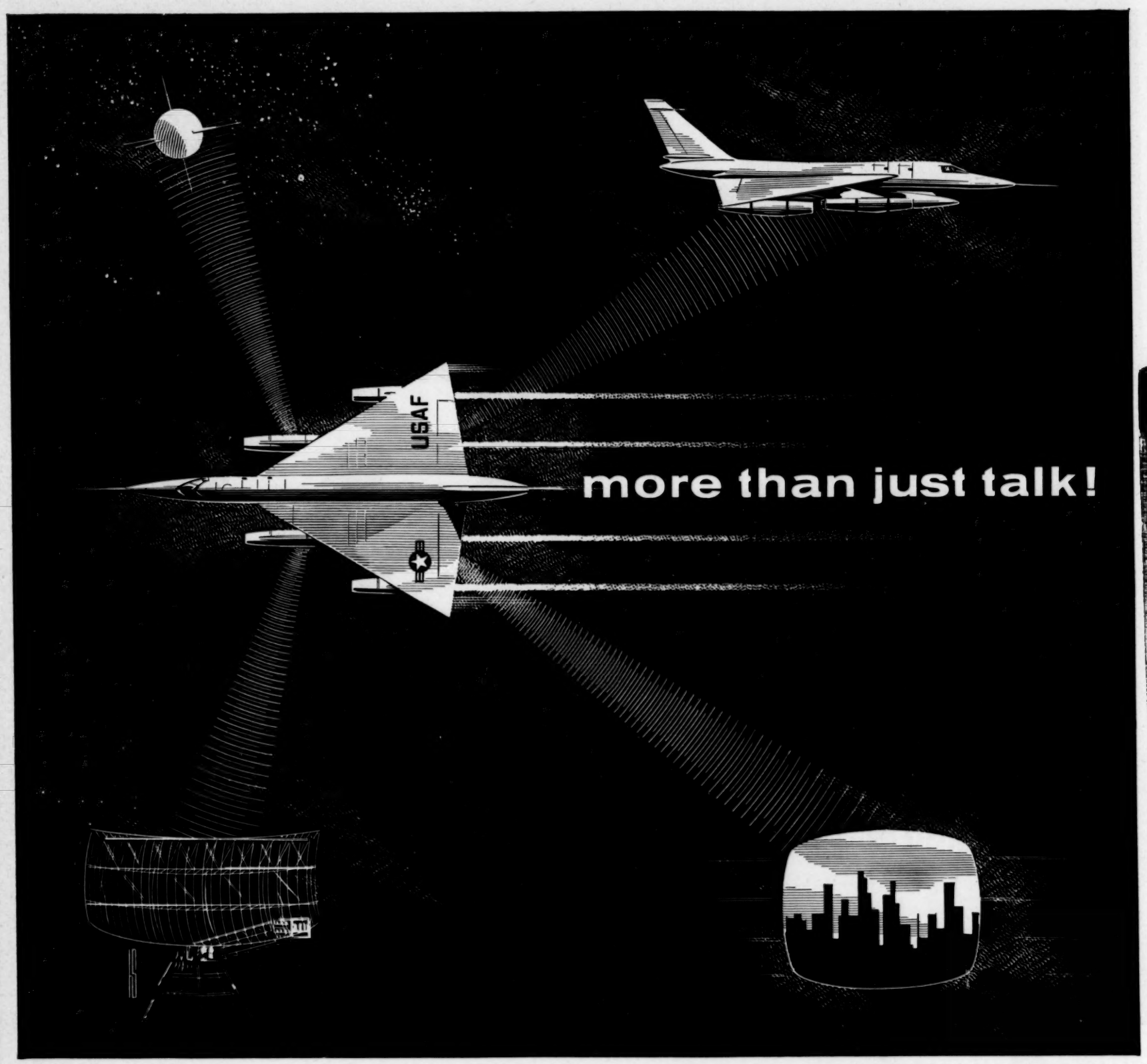
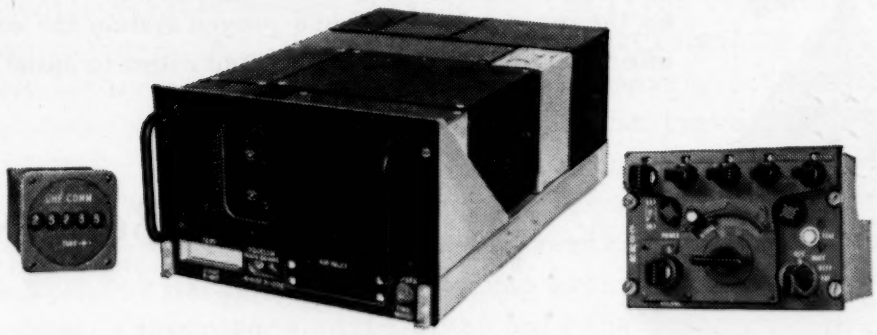


Magnavox continues to maintain a position of leadership in the airborne communications field.

Magnavox engineering, in conjunction with the Air Force, has developed an advanced airborne communication system that is designed to meet the requirements of the future. Utilizing wide band techniques, such functions as television relay for bomb damage assessment, data link for control and identification, and many other forms of air-to-air and air-to-ground communications can all be realized over the same equipment as used for voice.

Magnavox

AN/ARC-50 SYSTEM



COMMUNICATIONS | RADAR | DATA HANDLING | ASW | MISSILES

THE MAGNAVOX CO. • DEPT. 414 • *Government and Industrial Division* **• FORT WAYNE, IND.**

Circle Number 54 on Reader-Service Card

It's easy, when you know how.

Once we merely breathed the air, now we inhabit it. Millions of people have flown. And the largest percentage did it on American Airlines.

American's know-how is one reason flying is easy today. Look at the history of commercial aviation. You'll find that one airline has been responsible for these advances:

The DC-3, the plane that made commercial aviation, was built to American's specifications.

The first non-stop, round-trip, transcontinental service was on an American DC-7, another plane built to our specifications.

We were the airline to pioneer weather radar. The first to have transcontinental jet service. The first to build a jet-age maintenance plant. The first airline to be equipped with DME (Distance Measuring Equipment), the most significant advance ever made in airline navigation, even beyond radar.

Today, American offers 707 Astrojets,* the first commercial airliners to be powered with fan-jets, the engines that opened Jet Age: Stage II.

When experienced travellers pick an airline, it's usually American. And there are obvious reasons why.

*Service mark of American Airlines, Inc.

AMERICAN AMERICA'S LEADING AIRLINE

To fly faster than time itself...

Here's how the Douglas trisonic jet would beat the clock on westbound flights

LV. NEW YORK 5:00 PM

AR. LOS ANGELES 3:30 PM
FLIGHT TIME—1 HR. 30 MIN.*

LV. SAN FRANCISCO 8:00 AM

AR. HONOLULU 7:35 AM
FLIGHT TIME—1 HR. 35 MIN.*

LV. TOKYO 9:00 AM

AR. BANGKOK 8:50 AM
FLIGHT TIME—1 HR. 50 MIN.*

LV. BEIRUT 12:30 PM

AR. LONDON 11:55 AM
FLIGHT TIME—1 HR. 25 MIN.*

LV. PARIS MIDNIGHT

AR. NEW YORK 8:10 PM
FLIGHT TIME—2 HRS. 10 MIN.*

**Includes take-off and landing time.*

Trisonic jets that would land you in Los Angeles 2 hours earlier than your take-off time in New York are feasible says a late Federal study. Douglas officials say they could be operational by the early 1970's.

A 2100 mph civilian jet transport that would fly 13 miles high, cross the continent in one hour and thirty minutes*, and use present jet runways is on the drawing boards at Douglas.

Such an airplane is needed—says a recent Federal Aviation Agency study made with White House approval—to maintain U.S. leadership in commercial aviation. This is important because the export value of aircraft and parts in 1960 was $1.4 billion or 5.2% of total U.S. exports!

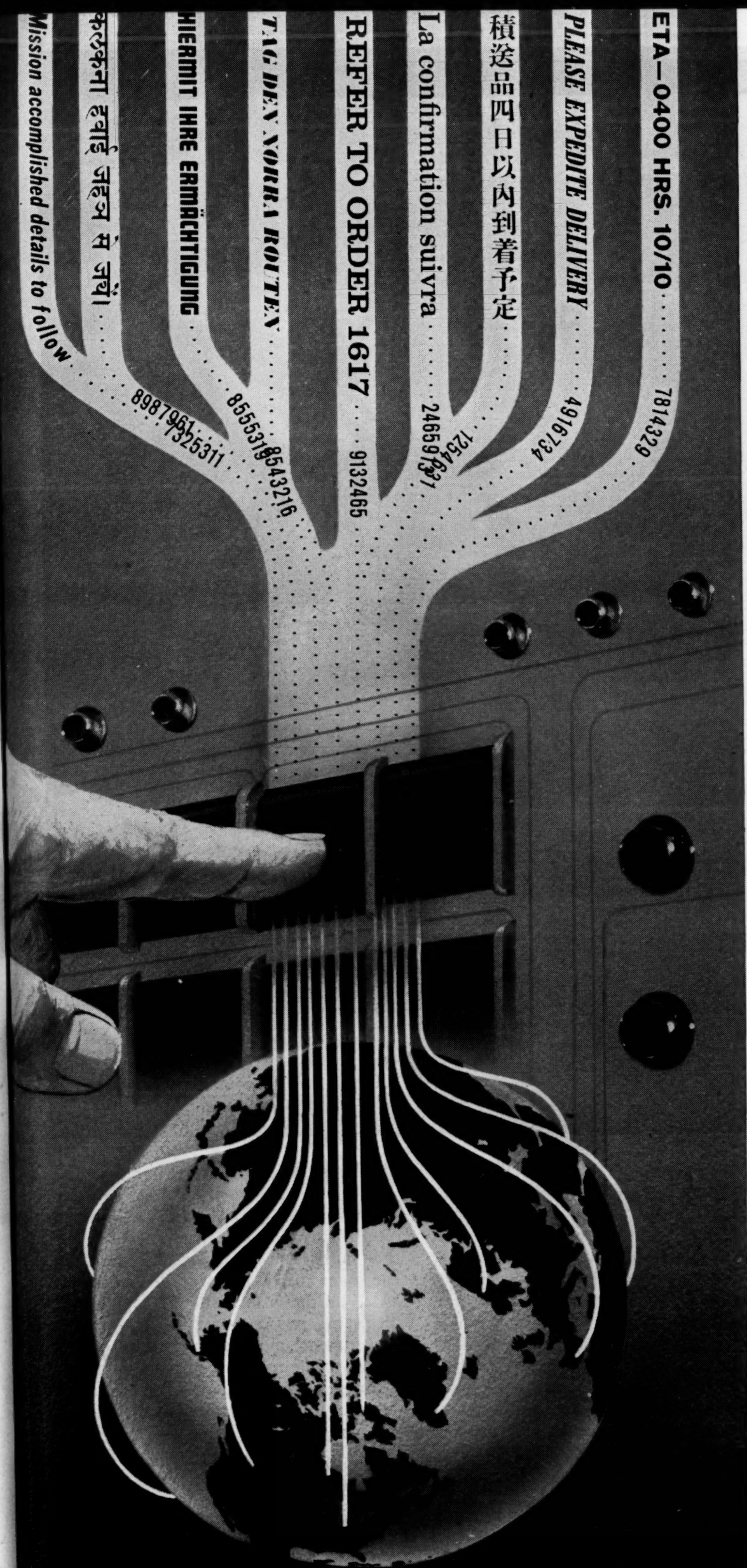
The study also notes that substantial government assistance would be needed to underwrite the $500 to $550 million estimated development costs.

Douglas believes that the estimated market of 200 to 300 Mach 3 aircraft would more than repay these development costs.

They are backing this belief with continuing studies based on 15 years experience with missiles, supersonic and hypersonic aircraft...to bring the trisonic civilian jet transport to reality at the earliest possible date.

DOUGLAS

MISSILE AND SPACE SYSTEMS • MILITARY AIRCRAFT • DC-8 JETLINERS • RESEARCH AND DEVELOPMENT PROJECTS • GROUND SUPPORT EQUIPMENT • AIRCOMB® • ASW DEVICES



IN DATA PROCESSING...

ITT MOVES FASTER THAN THE TIMES

NEW ITT DIGITAL SYSTEM IS READY FOR THE WORLDWIDE COMMUNICATION NETWORKS OF THE 1970's. When it comes to meeting the complex needs of modern communications systems, the new ITT-025 is a long stride ahead of its field. This sophisticated data processor and message switching center is designed to meet the automation requirements of the communications and data processing systems of the future.

The ITT-025, already in use as the heart of the Strategic Air Command's global communications system, stands ready to make major contributions in areas where efficiency and speed are critical. Air traffic control, automatic check-out systems, complex simulator systems and automatic message processing and switching are examples of its wide range of application.

For ultra-fast data processing of complex multiple inputs and outputs, the ITT-025 features solid state-logic, stored program and multisequence operation accommodating 256 interleaved jobs! It services 128 input and 128 output lines at multikilobit rates, storing 400 million bits for transmission and system operation. Automatic alternate routing, complete error-checking including correction by automatic retransmission, and receipting of all messages are inherent in the design.

The ITT-025 typifies the comprehensive capabilities of ITT for managing complete programs simultaneously under the Air Force's concept of concurrency. ITT Federal Laboratories moves faster than the times, achieving an absolute minimum lead time between initial concept and delivered results.

ITT

FEDERAL LABORATORIES
500 WASHINGTON AVENUE, NUTLEY, NEW JERSEY
CLIFTON, N. J. • FORT WAYNE, IND. • SAN FERNANDO & PALO ALTO, CAL.
DIVISION OF INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION

AVIONICS ▪ COMMUNICATIONS ▪ MISSILE AND SPACE SYSTEMS ▪ PHYSICAL SCIENCES ▪ ELECTRONIC DEFENSE

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GARRETT-U.S. AIR FORCE 'SPUR'

..one answer to America's future power needs in space

The joint U.S. Air Force-AEC Project SPUR is a research and development program being conducted by an industry team of Garrett, Aerojet-General Nucleonics (reactor) and Westinghouse, Lima (generator) to provide a power source to produce 300-1000KW electrical power in space for one year or more. Power is obtained by conversion of nuclear fission energy to mechanical (shaft) power with a potassium vapor turbine. Equipment includes: reactor, primary and secondary loop pumps, boiler, turbo-generator and condenser-radiator.

Long lead time is essential to the development of large nuclear space power systems. Present methods of power generation would require an impractical heat rejection surface nearly the size of a football field for a power output of one megawatt—power which will be needed for critical space missions already in the planning stage.

Garrett's AiResearch Divisions have now completed the initial SPUR design studies and proved the project's feasibility to supply continuous accessory power and low thrust electrical propulsion in space for long periods of time.

Cutting projected 1 MW power systems to 1/10th the size and 1/5th the weight of present power systems under development will be possible because of SPUR's capability to operate at higher temperatures, thereby sharply reducing the required radiator area.

Garrett has been working with the Air Force and the Atomic Energy Commission on SPUR as the prime contractor for more than one year and has more than five years of experience in space nuclear power development. Also an industry leader in high speed rotating machinery, heat transfer equipment, metallurgy and accessory power systems, the company is developing design solutions for SPUR in these critical component system areas.

THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

Los Angeles 45, California • Phoenix, Arizona

Systems and Components for: AIRCRAFT, MISSILE, SPACECRAFT, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

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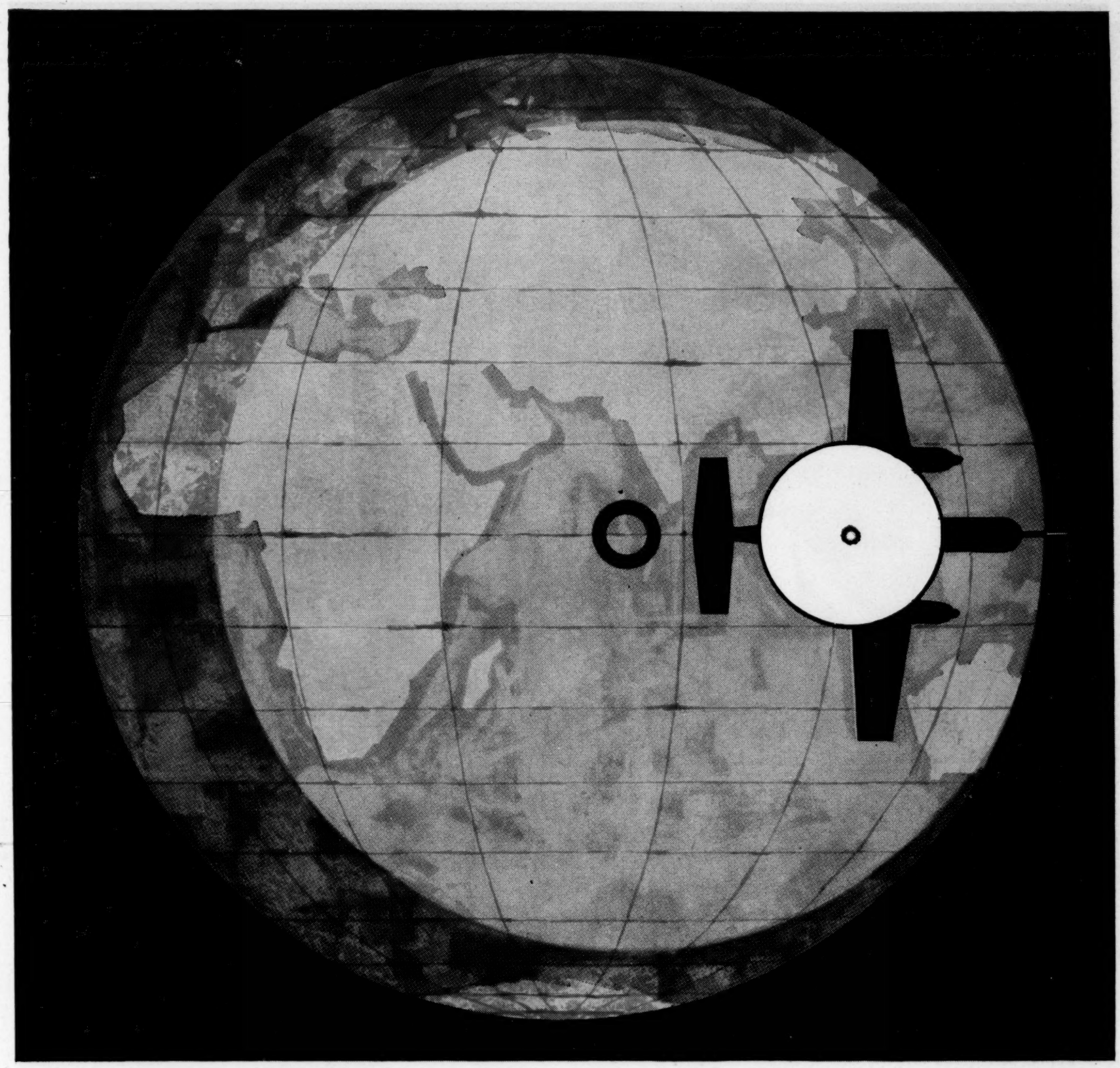

Brunswick Rotodomes - New Eyes and Ears of the Fleet!

Grumman Hawkeye carrier-based A.E.W. aircraft with a Brunswick-built rotodome gives new early warning capability to the Navy.

The Dalmo-Victor Division of Textron Inc. assigned Brunswick the task of fabricating the newest and most sophisticated of rotodomes. Brunswick's vast experience in fabricating large plastic-metal structures of sandwich construction assured the customer and the Navy of receiving a completely reliable product.

This large, complicated structure is another example of Brunswick's capability in the field of reinforced plastics and metal honeycomb. Whether the requirement be for a small structural unit such as a missile radome operating at high frequency, a large composite structure such as the rotodome, large reflectors or ground domes, you can count on Brunswick's project experience to accomplish your most difficult assignments.

In addition, Brunswick offers imaginative scientists and engineers to provide a searching approach to materials and fabrication techniques and electronic know-how. Complete testing and quality control facilities assure the success of all programs.

Interested engineers will find it rewarding to discuss career futures with Brunswick, an equal opportunity employer. Write or call Brunswick Corporation, Defense Products Division, 1700 Messler Street, Muskegon, Mich.

MAKES YOUR IDEAS *WORK*

Brunswick CORPORATION

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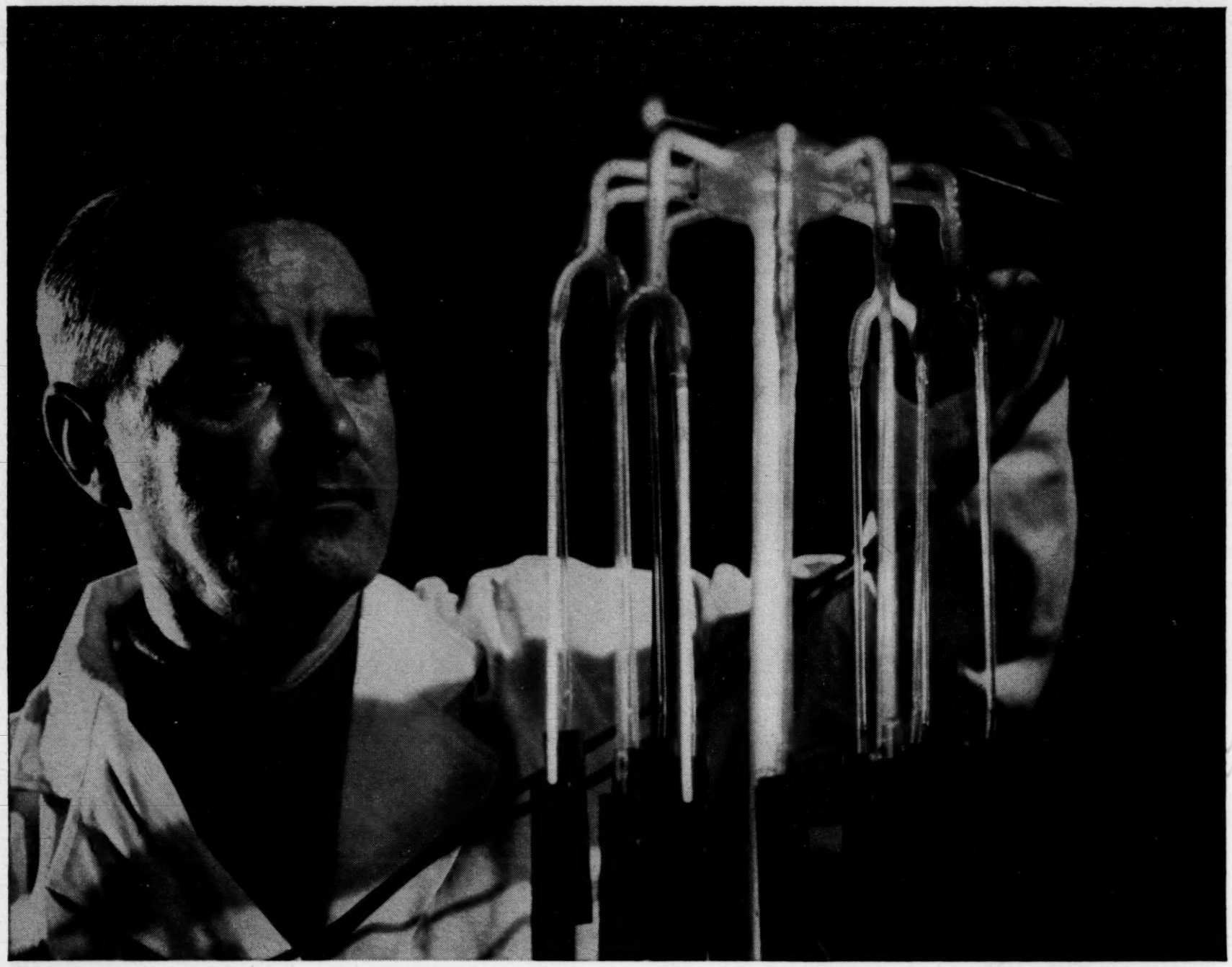

LIONEL: Instrumentation for Radiation Research

Research & Test programs for government and industrial nuclear applications require extensive instrumentation, systems and components, for detection, control, and safeguarding.—▪—The Lionel Corporation produces such equipment. We offer the complete Anton line of alpha, beta, gamma, neutron detector tubes and chambers; missile/satellite radiation probes; transistorized, portable alpha, beta, gamma survey meters; portable or rack-mounted air particle monitors; portable check-out monitors; radiation ratemeters...and many other similar type instruments. The above photograph, for example, shows an Anton radiation detection tube being tested under vacuum.—▪—In addition, our Nucleonics Division not only builds and tests such equipment, but is highly qualified to design and develop complete instrumentation and detection systems for specific applications required by those engaged in the various branches of radiation research.—▪—The Lionel Corporation presents a vast capabilities complex, each division solidly staffed and well equipped with modern, efficient laboratory and production facilities. Our extensive experience in nucleonics, ordnance, electronics, missilry, and communications makes Lionel a logical and worthy source for the development and delivery of your projects...from components through systems.

We welcome your further inquiry...and suggest that you request a copy of our new capabilities brochure, "LIONEL: A New Force."

THE LIONEL CORPORATION *Dept. 39-CV, Hoffman Place, Hillside, N. J.*

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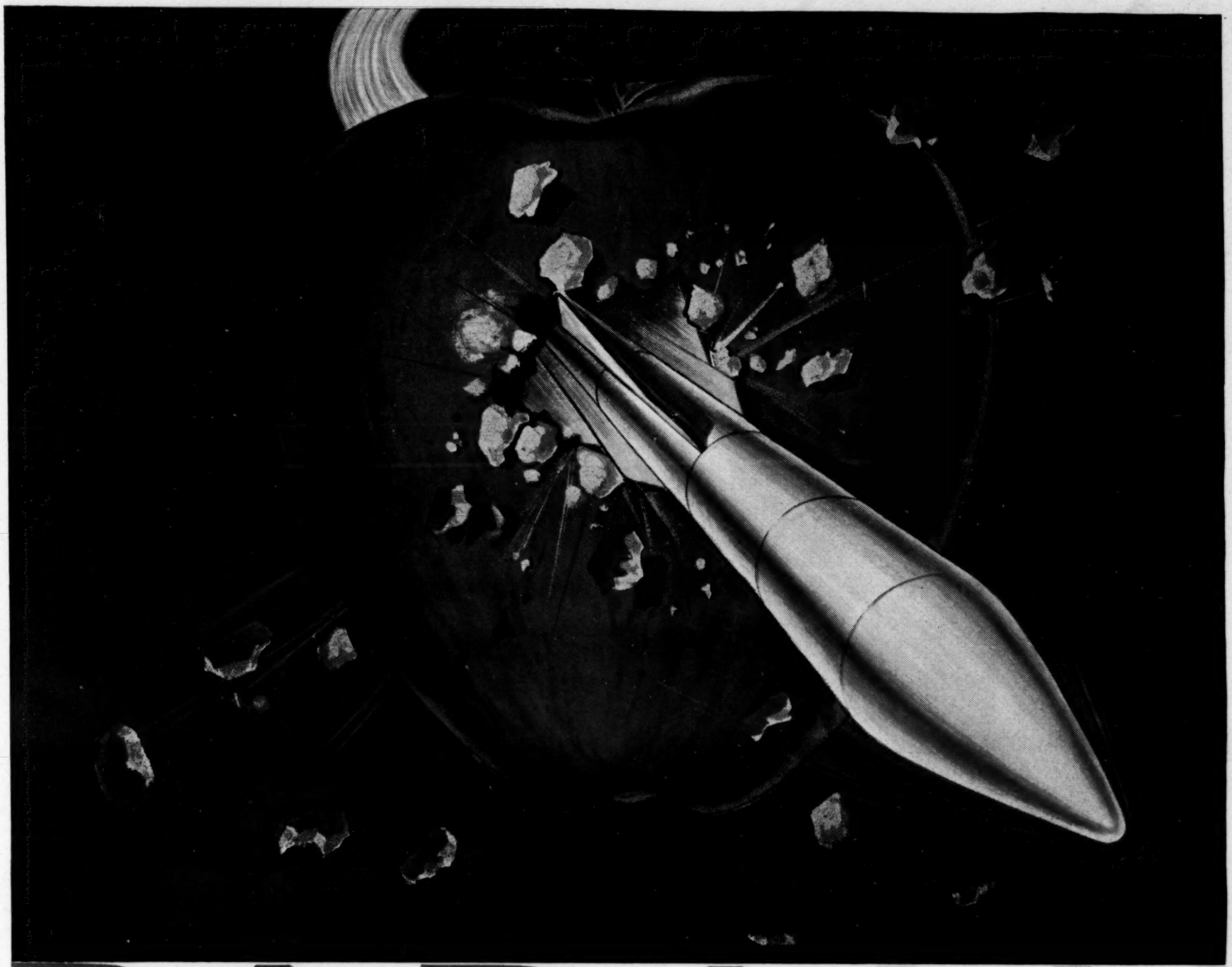
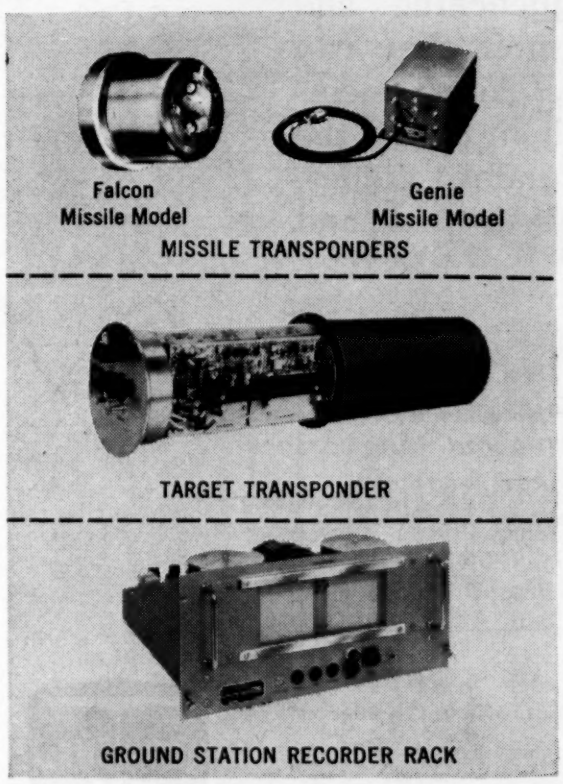


PARAMI

TO SCORE "WILLIAM TELL 1961" WEAPONS MEET



Once again, the Parami Miss Distance Indicator system will score the William Tell Weapons meet at Tyndall AFB. No other off-the-shelf system covers the effective ranges of all the missiles—no other system scores with the accuracy of Parami.

When the Air Defense teams fire Falcons, Sidewinders, and Genies at the Firebee drones, Parami transponders in the missiles and targets will be talking to each other and the ground station will be eavesdropping with pen and paper in hand, recording the score of each firing for the meet referees within seconds.

PARSONS *Electronics*

THE RALPH M. PARSONS COMPANY

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LONDON
NEW YORK
PARIS
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OFFICES IN OTHER PRINCIPAL CITIES THROUGHOUT THE WORLD

ELECTRONICS DIVISION

151 South De Lacey Avenue, Pasadena, California

WORLD WIDE SERVICES: APPRAISALS AND ECONOMIC STUDIES • ARCHITECT-ENGINEERING • CONSTRUCTION • ELECTRONIC SYSTEMS AND COMPONENTS • MINING AND METALLURGICAL ENGINEERING • PERSONNEL TRAINING • PETROLEUM-CHEMICAL ENGINEERING PETROLEUM PRODUCTION SYSTEMS • PLANT OPERATION • POWER PLANT ENGINEERING • WATER DEVELOPMENT AND SYSTEMS

KNOW YOUR ALLOY STEELS . . .

This is one of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

How Alloy Steels Respond to Induction Hardening

In the induction-hardening process, steel is first heated above the transformation range by means of electrical induction, then quenched as required. Special equipment is needed, and heat is developed as follows:

High-frequency alternating current passes through a coil or inductor, with the result that a magnetic field is created in the coil. When the piece to be treated is placed in this field, it is heated rapidly by induced energy. With the various types of induction-heating equipment, the process is capable of surface- or case-hardening to various controlled depths; however, through-hardening can be obtained with certain alloy steels. Ferrous metals that respond well to induction hardening include numerous grades of both alloy and carbon steels, as well as hardenable stainless steel and plain or alloyed cast iron.

As a rule, when alloy steels which contain non-carbide-forming elements, such as nickel, are heated by induction, the usual hardening temperatures can be used. But with alloy steels that do contain carbide-forming elements such as chromium, molybdenum, and vanadium, the hardening temperature must be increased if the normal effect of the alloying elements is desired.

Hardness obtained by the induction process is a function of the carbon content and prior structure, just as it is when conventional heating methods are used. Nevertheless, higher surface-hardness values for a given carbon content have often been noted in parts subjected to surface induction-hardening. The extra hardness may be as much as five Rockwell C points for steels of 0.30 pct carbon.

As pointed out previously, the induction method requires special equipment. However, it possesses several marked advantages, including speed of heating and cleanliness of operation. Pieces heated by induction are usually subject to a minimum of scaling and distortion. Moreover, induction-hardening equipment is very compact and therefore conserves floor space.

If you would care to know more about the induction hardening of alloy steels, please communicate with our technical staff. Bethlehem metallurgists have made a thorough study of the subject, including the many details of quenching and tempering. Call them if they can help you in any way. And remember, too, that Bethlehem makes the full range of AISI standard grades, as well as special-analysis steels and all carbon grades.

This series of alloy steel advertisements is now available as a compact booklet, "Quick Facts about Alloy Steels." If you would like a free copy, please address your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa.

Steel

for Strength
. . . Economy
. . . Versatility

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA. *Export Sales:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

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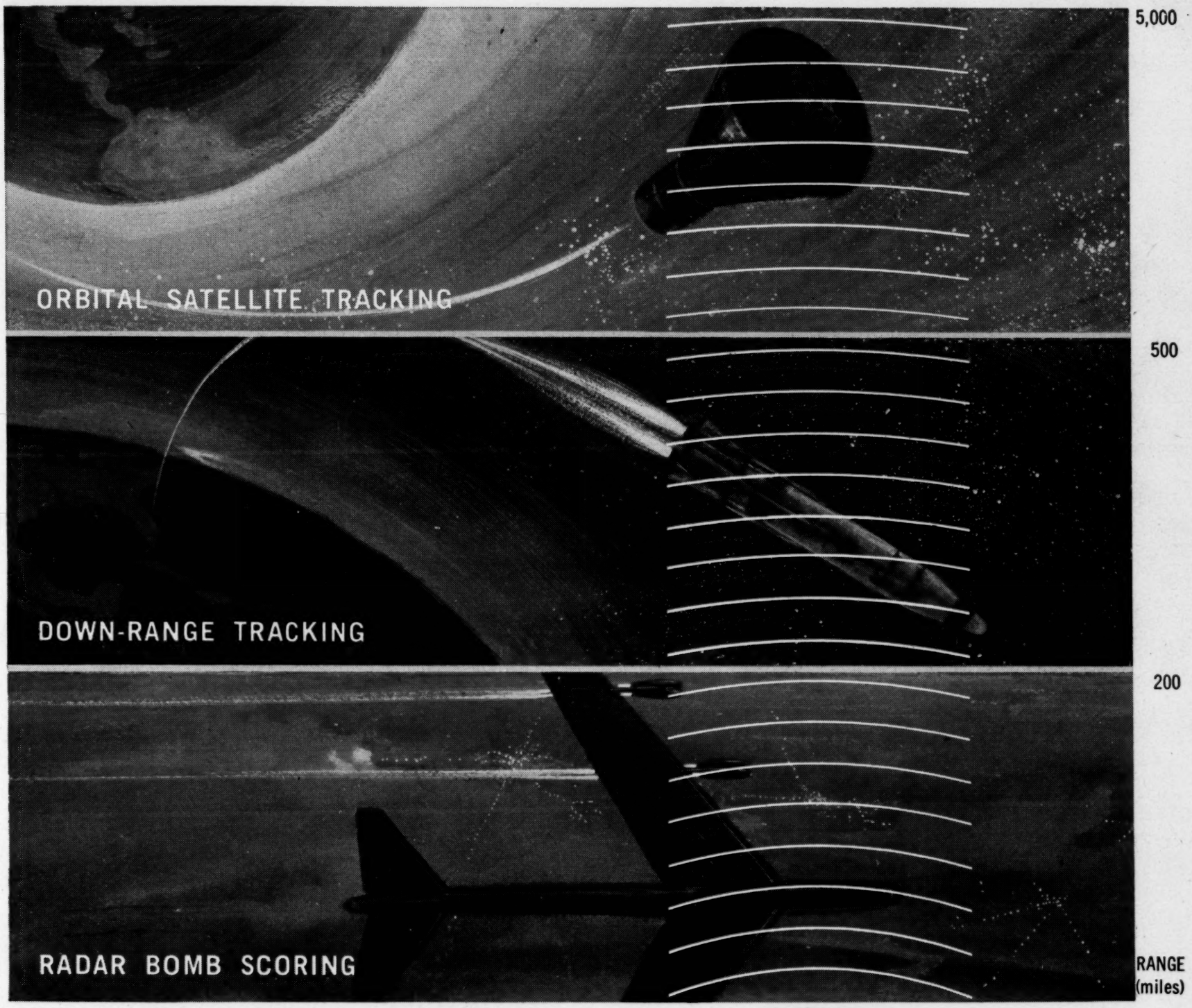


more than 15 years of

RADAR *by* Reeves

THERE'S NO SUBSTITUTE FOR EXPERIENCE

Orbital Satellite Tracking — Discoverer, Midas, Mercury — Over three years of proven field experience in all aspects of satellite tracking.

Down-Range Tracking — Reeves equipment, installed in the early days of Canaveral and White Sands, is still functioning with proven accuracy after nine years of continuous use.

Radar Bomb Scoring — Fifteen years of proven experience in the design, installation, and servicing of complex radar equipment for the scoring of simulated bombing runs.

Whatever your radar requirements may be, Reeves has technical, production, and field-proven experience to meet your requirements.

REEVES INSTRUMENT CORPORATION

A Subsidiary of Dynamics Corporation of America • Roosevelt Field, Garden City, New York

Qualified engineers seeking rewarding opportunities in these advanced fields are invited to get in touch with us.

SPACE SYSTEMS:

FROM TALENTS TO HARDWARE

LOOK TO GENERAL PRECISION FOR DEVELOPMENT, PRODUCTION AND SYSTEMS MANAGEMENT

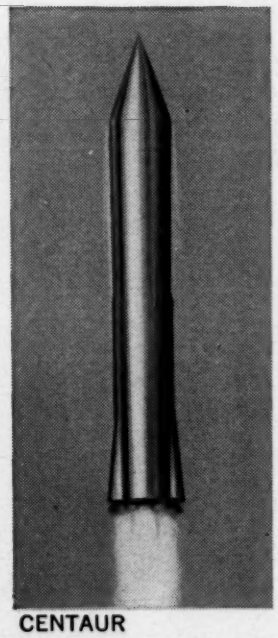
The talents and capabilities of the four divisions of General Precision, Inc., are heavily represented in the latest space systems, as well as in space-age hardware and weapons of all categories. The divisions are responsible for some system, subsystem or component on virtually every space vehicle, satellite, missile, rocket and aircraft now in operation or development.

To make these broad capabilities available to the fullest of their combined potential, General Precision, Inc., has consolidated its four divisions for the systems management of major new space and weapons projects.

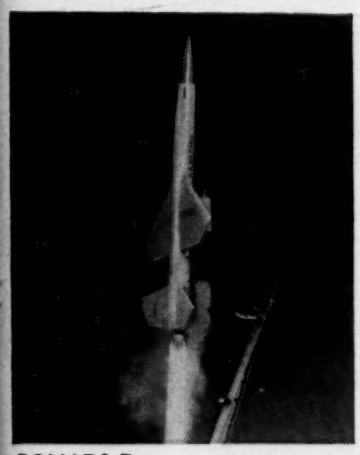
A major space program can now draw upon more than 2½ million square feet of combined General Precision floor space and over 16,000 General Precision employees, including 4,500 scientists, engineers and technicians.

This combination of talents and facilities, backed by the corporate financial resources of General Precision, Inc., makes it possible to develop, produce and manage a space system as an integrated package.

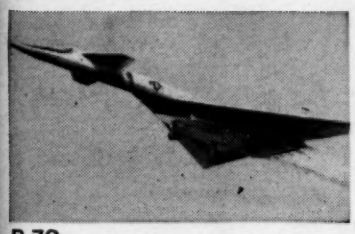
MIDAS



CENTAUR



BOMARC-B



B-70

ATLAS

POLARIS

GENERAL PRECISION'S DEMONSTRATED CAPABILITIES:

NAVIGATION, GUIDANCE AND CONTROL

SAMOS
MIDAS
ATLAS
PERSHING
POLARIS
SUBROC
BOMARC-B
SKYBOLT
B-70
B-52

COMPUTER TECHNOLOGY

CENTAUR
POLARIS
ASROC
SUBROC
NAVY AIRBORNE BOMB-NAV
FAA AIR TRAFFIC CONTROL

DETECTION, TRACKING, ACQUISITION AND FIRE CONTROL

VENUS STUDY
TALOS
NAVY ASW FIRE CONTROL
POLARIS

SIMULATION AND LOGISTIC SUPPORT

CENTAUR
BOMARC-B
ASROC
SUBROC
B-58
F-106A
A3J-1
F8U-1 & 2
F11F-1
DC-8
707
880

TODAY'S DEMONSTRATED ACHIEVEMENTS SHAPE TOMORROW

GPL
KEARFOTT
LIBRASCOPE
LINK

GENERAL PRECISION, INC.

PRINCIPAL OPERATING SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION

92 Gold Street, New York 38, New York

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GCR studies and tests prove the reliable Solid Rocket can be happily wed to the Liquid Rocket. Product of this union—the Hybrid Rocket: number of stops and starts practically unlimited; thrust and speed control from 0 to 100 per cent; more specific impulse (I_{sp} and $I_{sp}d$) than any other non-cryogenic system. ■ The Hybrid is particularly well-suited for soft landings on airless celestial bodies, for highly accurate orbital changes of satellites and spacecraft, and for controllable defense missiles. **GRAND CENTRAL ROCKET COMPANY**

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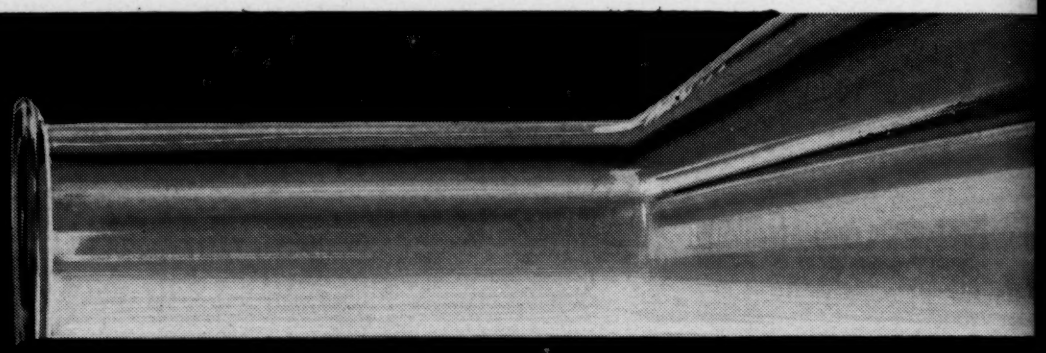

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Aviation Week and Space Technology

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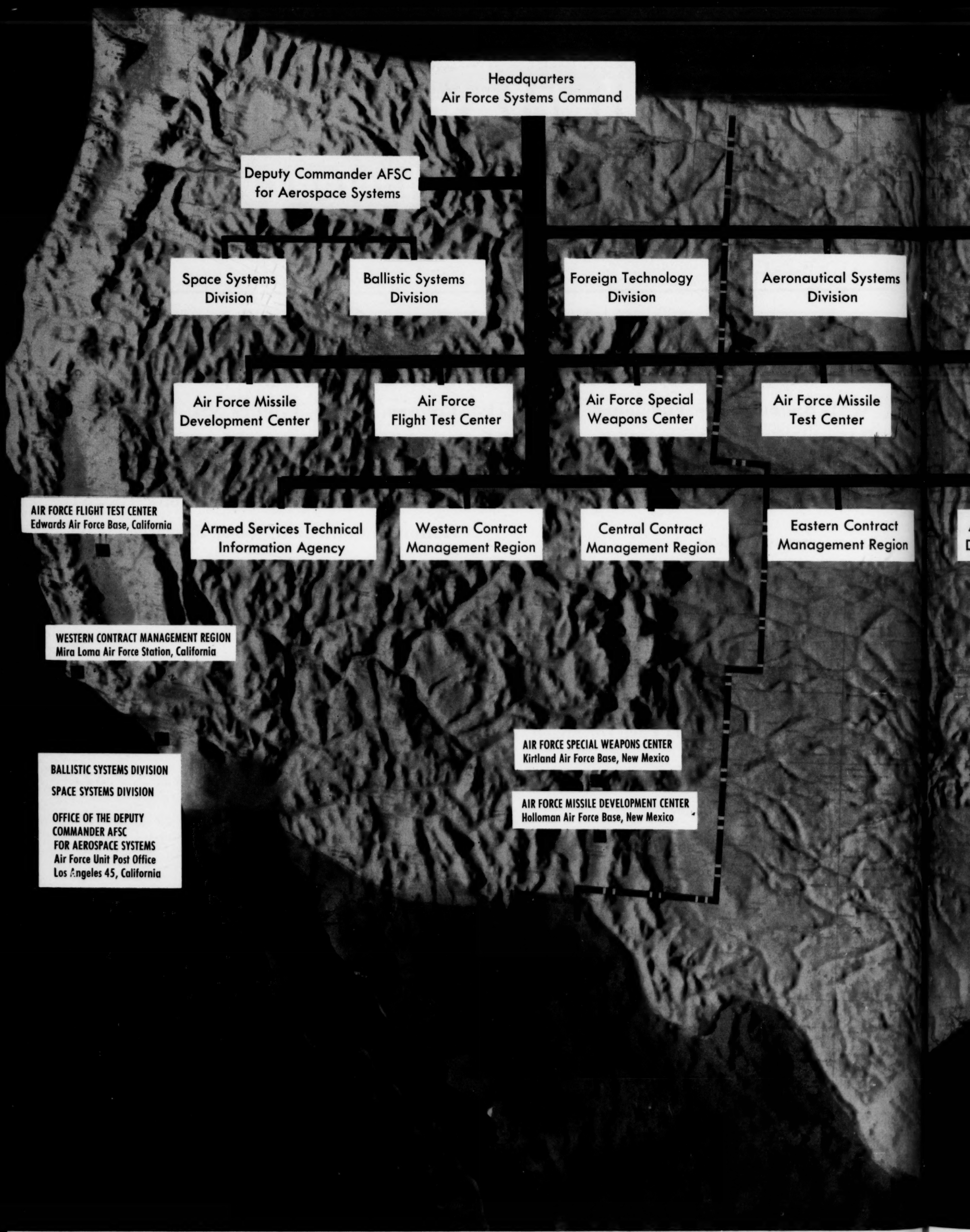
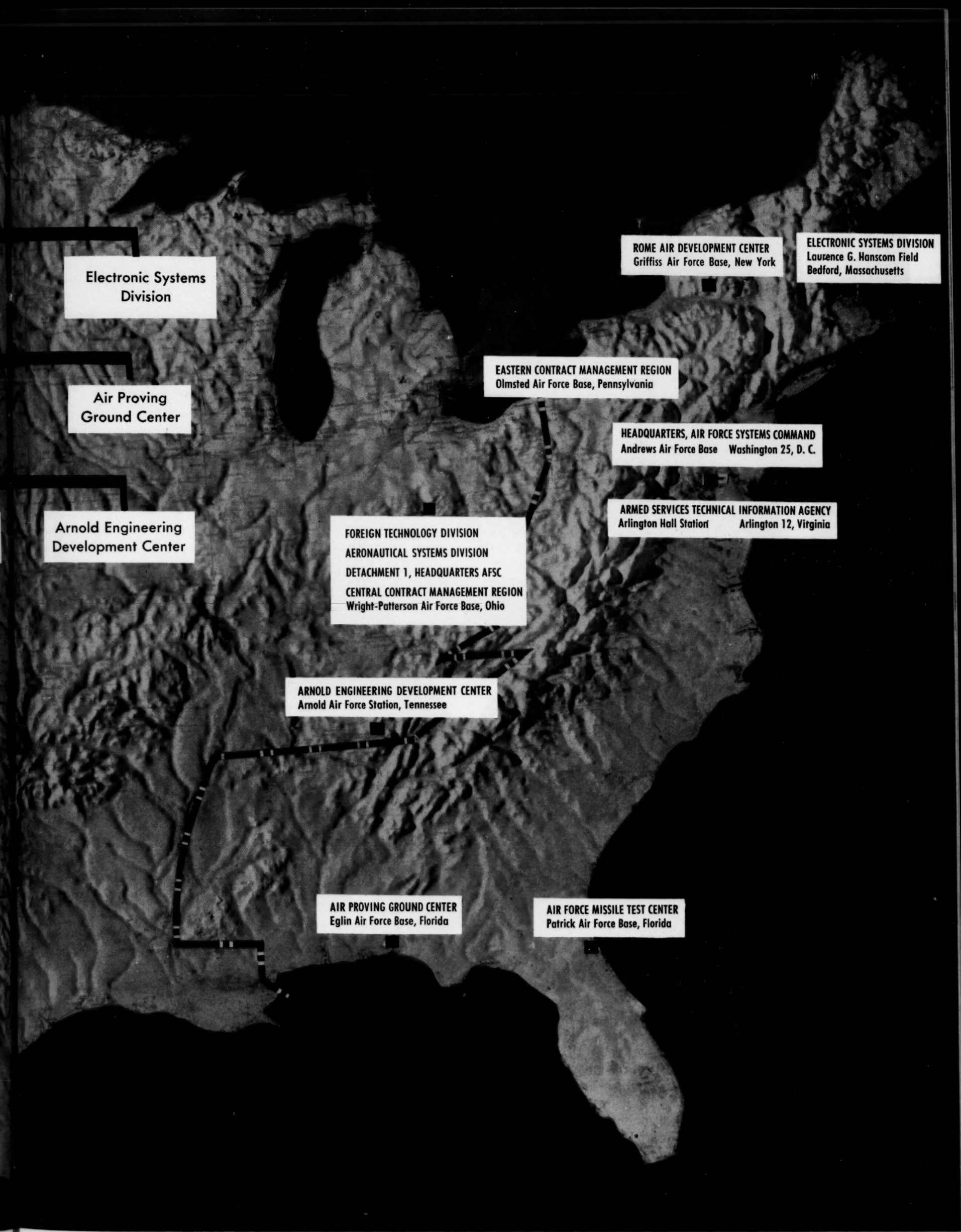
This special issue, devoted to the newly created USAF Systems Command, was written and edited by a special Aviation Week editorial task force consisting of David A. Anderton, Technical Editor; Irving Stone, West Coast Editor; Philip J. Klass, Avionics Editor; Edward H. Kolcum, Space Technology Editor; Larry Booda, Military Editor; assisted by William S. Reed, Andrew A. Keil and Ann Dunphy. Art direction was handled by Lawrence J. Herb, Art Editor.



USAF SYSTEMS COMMAND


Electronic Systems Division
Air Proving Ground Center
Arnold Engineering Development Center
ROME AIR DEVELOPMENT CENTER
Griffiss Air Force Base, New York
ELECTRONIC SYSTEMS DIVISION
Laurence G. Hanscom Field
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AIR FORCE MISSILE TEST CENTER
Patrick Air Force Base, Florida

Within the last twenty years the nation's scientific and military environment has undergone a radical change—a change so rapid and far-reaching that we refer to it as a "technological explosion." This explosion means two things. First, it drastically shortens the time we have to produce new military systems. Secondly, it has opened up the vast realm of space as a potential medium for military operations.

Against this background the Air Force Systems Command was created. Its mission is to provide the Strategic Air Command, Tactical Air Command, Air Defense Command and other using commands with the most up-to-date aerospace systems possible—and to provide them in time.

AFSC is the result of a far-reaching reorganization in the areas of research and development, systems production and procurement, and foreign technology. For the first time, all these elements in systems acquisition have been placed under a single manager.

Thus AFSC has been assigned a formidable task—but it has also been given the tools to do the job. The story of AFSC's varied activities needs to be known, for it carries out a responsibility that is vital to the continuing strength of the United States and the entire Free World.

B. A. Schriever

General, USAF, Commander AFSC

Systems Command Given New Functions

Responsibility for development, production cycles of weapon systems covers $60 billion in USAF funds.

Andrews AFB—Newly created Systems Command is tackling the most colossal job in post-war Air Force history. It has been given sole managerial responsibility for the research, development, testing, procurement and production of all new USAF weapon systems from inception to delivery to operational user commands.

This task now involves responsibility for about 40% of the annual USAF budget, including handling $7 billion in new procurement authority during Fiscal 1962. Systems Command will be responsible for a total of $60 billion in contracts during the full development and production cycle of the weapon systems now under its control. Total of 35,000 USAF contracts with industry will come under the command's managerial supervision.

The new Systems Command was activated officially on Apr. 1, 1961 under the command of Gen. Bernard A. Schriever. But its evolution into its present character is the result of a decade of USAF effort to cope with two dominant post-war problems. These problems are:

- **Increasing scope** and pace of the technological revolution spawned by jet and rocket propulsion, hypersonic aerodynamics, nuclear fission and avionics.
- **Increasing challenge** from the Soviet Union in developing the new technology into weapon systems across the entire technical spectrum from supersonic aircraft through ballistic missiles and space technology.

Evolutionary Cycle

This evolutionary cycle that eventually created the Systems Command began in 1951 when USAF concluded that the research and development job had outgrown the capabilities of the old Air Materiel Command. In April, 1951, most of the USAF technical resources then scattered among a half dozen commands, but mainly concentrated in the engineering division of Air Materiel Command, were transferred to the newly created Air Research and Development Command.

ARDC was given primary responsibility for research and development of new weapon systems but AMC still retained the function of procurement for these systems. ARDC and AMC operated together for an uneasy decade and attempted various methods of welding themselves into a workable combination, largely through the joint Weapon System Project Offices created for each new weapon system. The WSPOs were manned by both ARDC and AMC personnel in addition to representatives of the eventual combat and training commands destined to use the new system.

Control of the WSPO rested with ARDC in the early development phase of the new weapon system and then shifted to AMC when procurement and production became the dominant phase. This system of shifting responsibility was never really considered satisfactory by the two commands involved nor the industrial contractors with whom they dealt. As weapon systems increased in technical complexity the flaws in the system became more serious.

Finally, when the intercontinental ballistic missile systems reached their base construction, installation and check-out phase in 1960 these complex and shifting responsibilities became totally inadequate and USAF took another hard look at ARDC-AMC relationships in the winter of 1961.

The results of this appraisal created the Systems Command, and assigned it the single managerial responsibility for new weapon systems through their entire development and initial production to delivery as combat-ready systems. Principal point of the reorganization was to transfer the procurement function for new weapon systems from AMC to Systems Command, although other important organizational changes and new philosophy had been fermenting for the previous year in ARDC under the aegis of Gen. Schriever and top-level USAF committees.

Names Abolished

The re-organization abolished the names of the two groups that had been involved in the shadowy control pattern of the past decade and created three new organizations. These three organizations are:

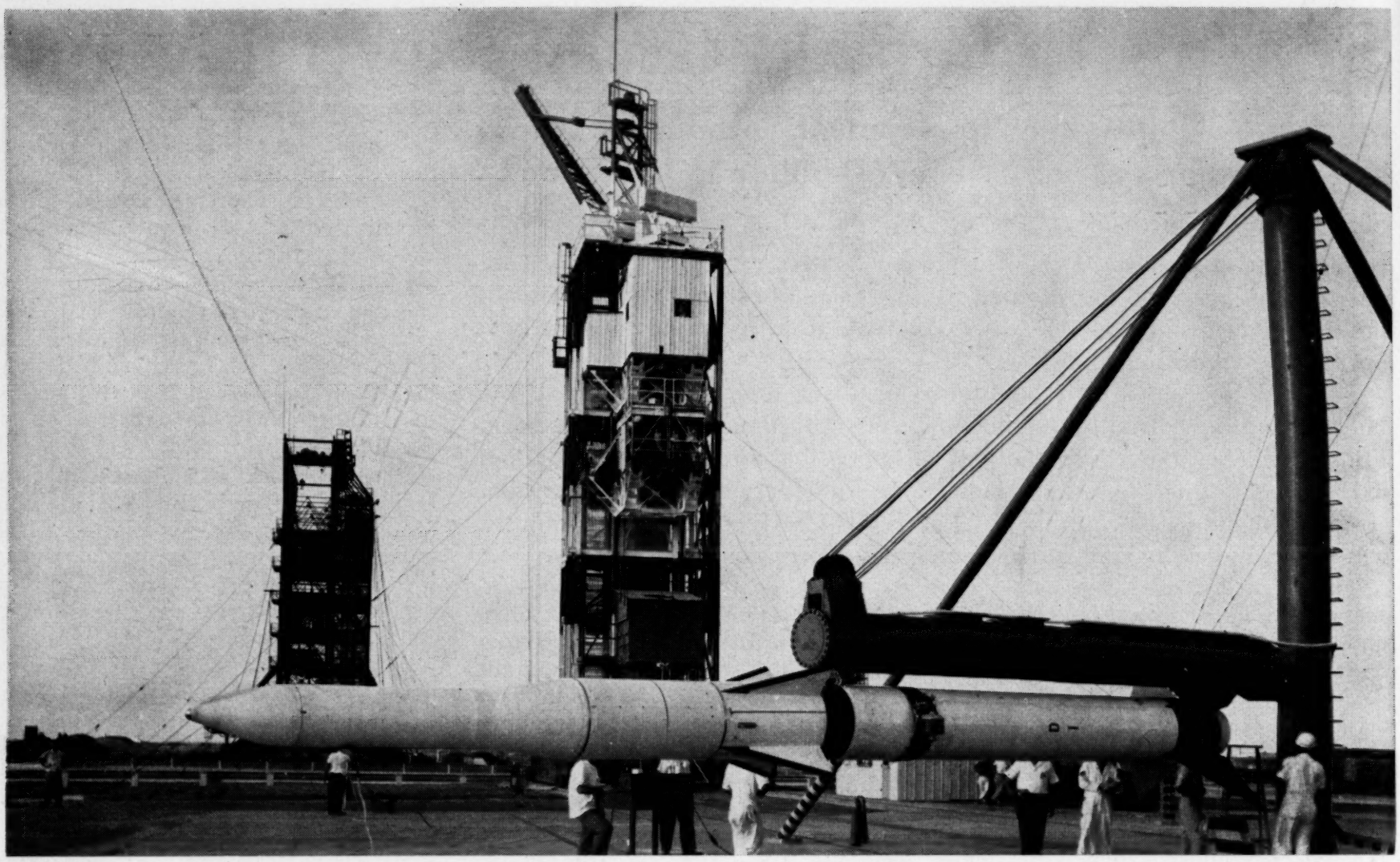
- **Systems Command,** consisting of all of the former ARDC functions, facilities and personnel except those devoted to basic research, plus systems procurement personnel, contract management regions including Air Force plant representatives, all of whom formerly were part of Air Materiel command. This gave Systems Command complete managerial control of new weapon systems from initial development to delivery to operational commands and added the procurement and post-contract administration functions.
- **Logistics Command,** consisting of all the remaining functions of AMC and charged with procuring all items of common usage for USAF and also for logistically supporting the weapon systems during their life with the operational user commands.
- **Office of Aerospace Research,** consisting of all of the former ARDC basic research facilities. These included the Office of Scientific Research in Washington, the geophysics and electronic research laboratories at Cambridge, Mass., the aeronautical research laboratory at Dayton, Ohio, and the European research office in Brussels. This new research organization reports directly to USAF's chief of staff and is aimed at placing more emphasis on basic research, a trend that had been desired but often frustrated since the earliest days of ARDC. There is some study now under way at top USAF levels as to whether the Office of Aerospace Research should be moved back into the Systems Command tent and a decision is expected before the end of the year.

Basic Effect

Basic effect of the re-alignment between Systems Command and Logistics Command was to move their former shifting and often confusing and indecisive interface out of the development cycle to the point where the major transfer of systems responsibility from developer to users would normally have occurred.

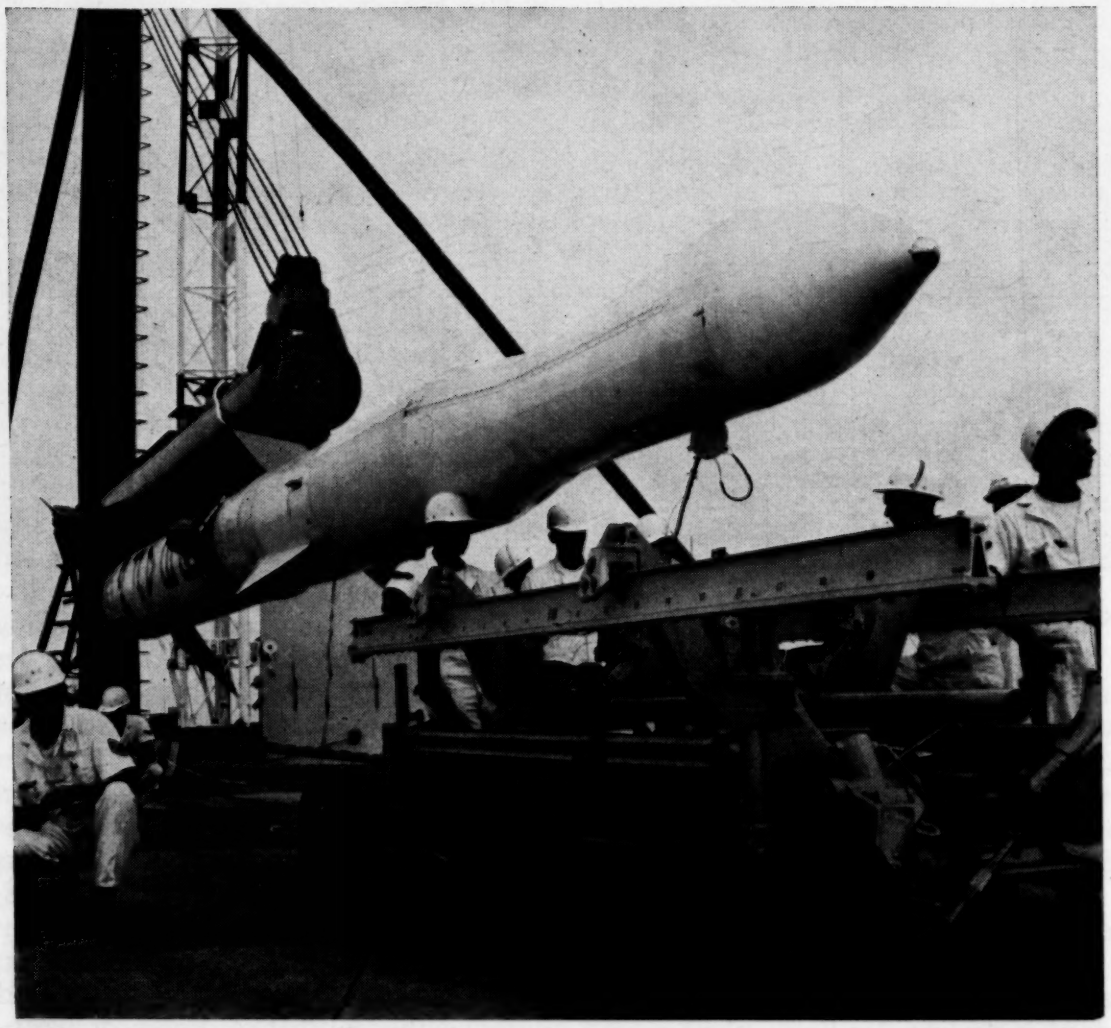
Logistics Command still figures in the logistics support planning for any new weapon system from its earliest developmental phase and works closely with Systems Command and the user commands within the Systems Program Office framework. But it no longer has any control or managerial responsibility for the new weapon system at any time during the development cycle. Its assumption of full logistic support authority comes at the same time the user command takes over the weapon system in a combat-ready condition from Systems Command. Until this transfer of combat-ready systems occurs the sole responsibility rests with Systems Command.

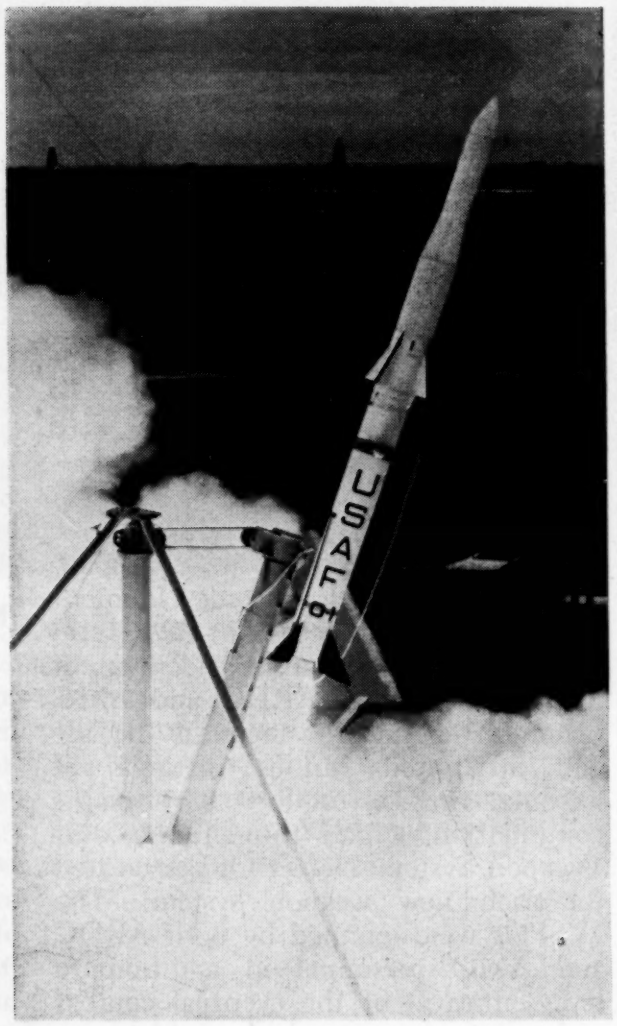
Basic goal of this shift was to shorten the development cycle, reduce costs and improve the combat-readiness of weapon systems delivered to the user commands. It is this yardstick that the



All-USAF crew prelaunches Blue Scout Jr. research and development rocket at Pad 18A, Cape Canaveral, Fla. Purpose of Blue Scout program is to collect data to support military space and weapon system development programs (AW Oct. 10, 1960, p. 62). Aeronutronic Division of Ford Motor Co. is prime contractor for the Blue Scout program; Ling-Temco-Vought, Inc., is manufacturer.

All-USAF Crew Launches Blue Scout Jr. Rocket





Blue Scout Jr. is launched by USAF crew Aug. 17 from boom set at 70-deg. angle. Other Blue Scout vehicles are fired vertically. Small spin rockets are clamped to upper portion of first stage; these rockets stabilize the first stage in flight.

Congress, Department of Defense and USAF headquarters will use in measuring the effectiveness of Systems Command operations.

Within the new Systems Command other basic organizational and philosophic changes have been implemented. Many of them came out of the experience of Gen. Schriever in managing the ICBM program during the years that he headed the Ballistic Missile Systems Division of ARDC. They are:

• **Shift in emphasis** on weapon system management from Systems Command headquarters to the operating divisions in the field.

• **Raising the managerial** and control level of the System Program Directors in each field division to provide them with both resources and authority required to run their specific programs.

• **Shifting emphasis** in Systems Command headquarters from systems control to a planning and managerial function aimed at improving command-wide performance.

• **Shifting emphasis** in the former ARDC centers to support of division programs and establishing closer division-center relations to replace the former direct ties between ARDC headquarters and the centers.

• **Developing special command** channels to handle exceptional problems or special projects with swift, technically sound decisions without creating special organizations for each new top priority problem.

Six Divisions

Systems Command field organization is now organized into six divisions and seven development and test centers. The divisions are:

• **Space Systems Division** commanded by Maj. Gen. Osmond J. Ritland and headquartered in the old Space Technology Laboratories complex at El Segundo, Calif. This was split off from the old Ballistic Missile Division of ARDC and the Ballistic Missile Center of AMC when growing military space requirements made the management of both ICBMs and space systems too complex for a single organization. In addition to the managerial complexity it became evident that the technologies required for space systems development were diverging from the ICBM technology.

• **Ballistic Systems Division** commanded by Maj. Gen. Thomas P. Gerrity and headquartered in the Arbor Vitae complex at Inglewood, Calif. In addition to the missile program director offices acquired from ARDC's Ballistic Missile Division, this group absorbed the parts of Ballistic Missile Center of AMC and the Army Corps of Engineers Ballistic Missile Construction Office.

• **Aeronautical Systems Division** commanded by Maj. Gen. Waymond A. Davis and headquartered at Wright-Patterson AFB. It consists of the personnel and functions of the ARDC Wright Air Development Center augmented by the former AMC Aeronautical Systems Center and AMC procurement personnel concerned with contracting for aircraft weapon systems and their supporting equipment, including air-to-ground missiles, powerplants and ground support equipment. The Aeronautical Systems Division responsibility extends from conventional aircraft operating in the atmospheric envelope such as the B-52H, F-105 and C-141 and their accompanying missile and support systems such as Hound Dog and Skybolt through the vehicles designed to operate both within this envelope and in outer space, such as Dyna-Soar and Aerospace Plane.

• **Electronic Systems Division** commanded by Maj. Gen. Kenneth P. Bergquist and headquartered at Hanscom AFB on the fringe of Boston. Primary responsibility of this division is the development of modern command and control systems combining the speed, scope and reliability required for effective command of modern weapon systems and nuclear armament. It was formed from the old Command and Control Development Division of ARDC and the former Electronics Systems Center of AMC and is the only division that has a center specifically assigned to its control—Rome Air Development Center, Griffiss AFB, N. Y.

• **Foreign Technology Division** commanded by Brig. Gen. Arthur Pierce consists primarily of the former Air Technical Intelligence Center at Wright-Patterson AFB. Under its new concept, it is designed to make increased use of existing intelligence-gathering agencies to provide a broader picture of the developing capabilities in foreign technologies, particularly that of the Soviet Union, and relate them to specific problems in each of Systems Command's major areas of technical interest. This is the only division that does not have managerial responsibility for any specific weapon systems.

• **Bioastronautics Division** commanded by Brig. Gen. Theodore Bedwell, Jr., will be created from existing Systems Command facilities such as the Aerospace Medical Laboratory at Wright-Patterson AFB and the Aero-medical Field Laboratory at Holloman AFB, plus acquisition of the Aerospace Medical Center and School at Brooks AFB, the personnel and epidemiological laboratories at Lackland AFB and the Aero-medical Field Laboratory at Ft. Wainwright, Alaska. This is a significant step in consolidating all of USAF's bioastronautics facilities and resources under single management and technical coordination. The new division will be activated Oct. 1 and will give Systems Command the largest capability in this critical area of space technology of any government agency.

If the Office of Aerospace Research is eventually transferred to Systems Command it would form a seventh operating field division but would probably retain its headquarters in Washington, D. C.

The split of what was formerly the Ballistic Missile Division into the Ballistic and Space Systems Division required creation of a special post. This is the Deputy Commander of Systems Command for Aerospace Systems (DCAS), now Lt. Gen. Howell M. Estes. The Ballistic and Space divisions between them now account for expenditure of about half Systems Command's total annual budget and are operating in the frontier areas of technology as well as in top-priority for weapon systems. They are also located in close geographic proximity to each other but across the continent from Systems Command and USAF headquarters.

Since the organization of the new divisions could not be handled in a simple split of former functions, personnel or facilities and involved allocation of specific resources from all of the previously-existing ARDC and AMC organizations, the Deputy Chief of Staff for Aerospace Systems has as one of his principal functions arbitrating the shifting of these resources into the new Systems Command divisional pattern.

Special Post

Thus it was deemed wise to create this special deputy commander's post to coordinate their efforts on the spot and to provide a common logistics and housekeeping support for both divisions, rather than create two separate support organizations on each other's doorstep Gen. Estes maintains only a small personal planning staff plus the support wing that serves both divisions for housekeeping functions.

There will also be shifting emphasis in the future between the two divisions with the indications that after Minuteman becomes operational and the basic responsibility shifts to Strategic Air Command and the Logistics Command, the Ballistic Systems Division workload and size will decrease considerably.

Space Systems Division will probably take the opposite direction with considerable expansion as the military role in space becomes more pronounced and complex. During this period of shifting emphasis Systems Command feels it necessary to have an over-all commander on the spot to allocate resources and supervise the required changes rather than attempt to handle this top-priority area by remote control solely from Sys-

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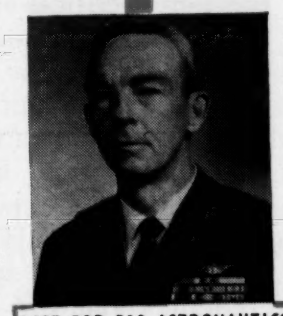

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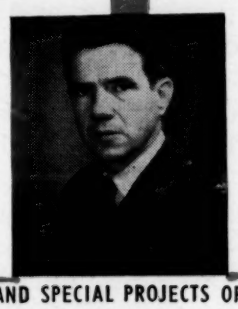

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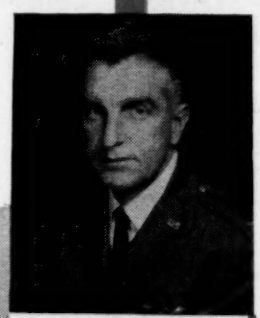

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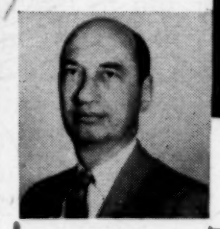

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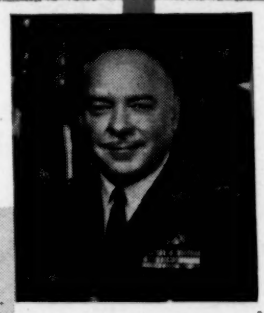

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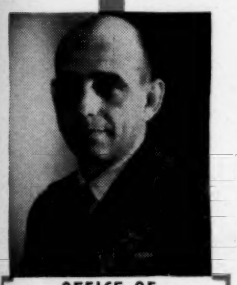

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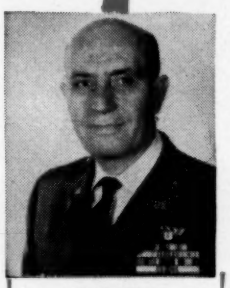

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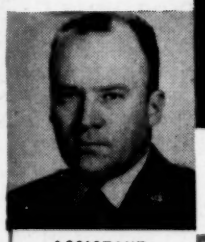

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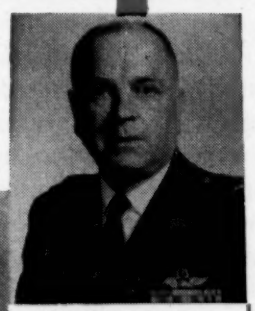

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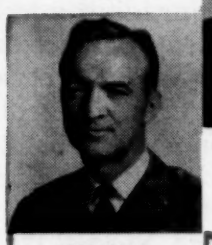

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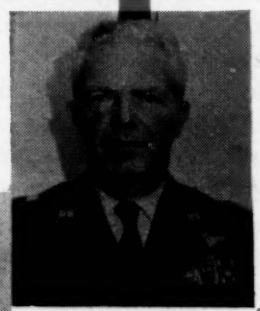

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Lt Col G. H. Wilson

- DIRECTORATE OF FOREIGN ACTIVITIES AND TECHNICAL APPLICATION
  Col M. J. Piatnitza
- DIRECTORATE OF FOREIGN TECHNICAL ANALYSIS
  Col W. F. Dallam

ARMED FORCES LIAISON OFFICERS
Navy: Capt R. Kolakowski
Army: Maj J. H. Proctor

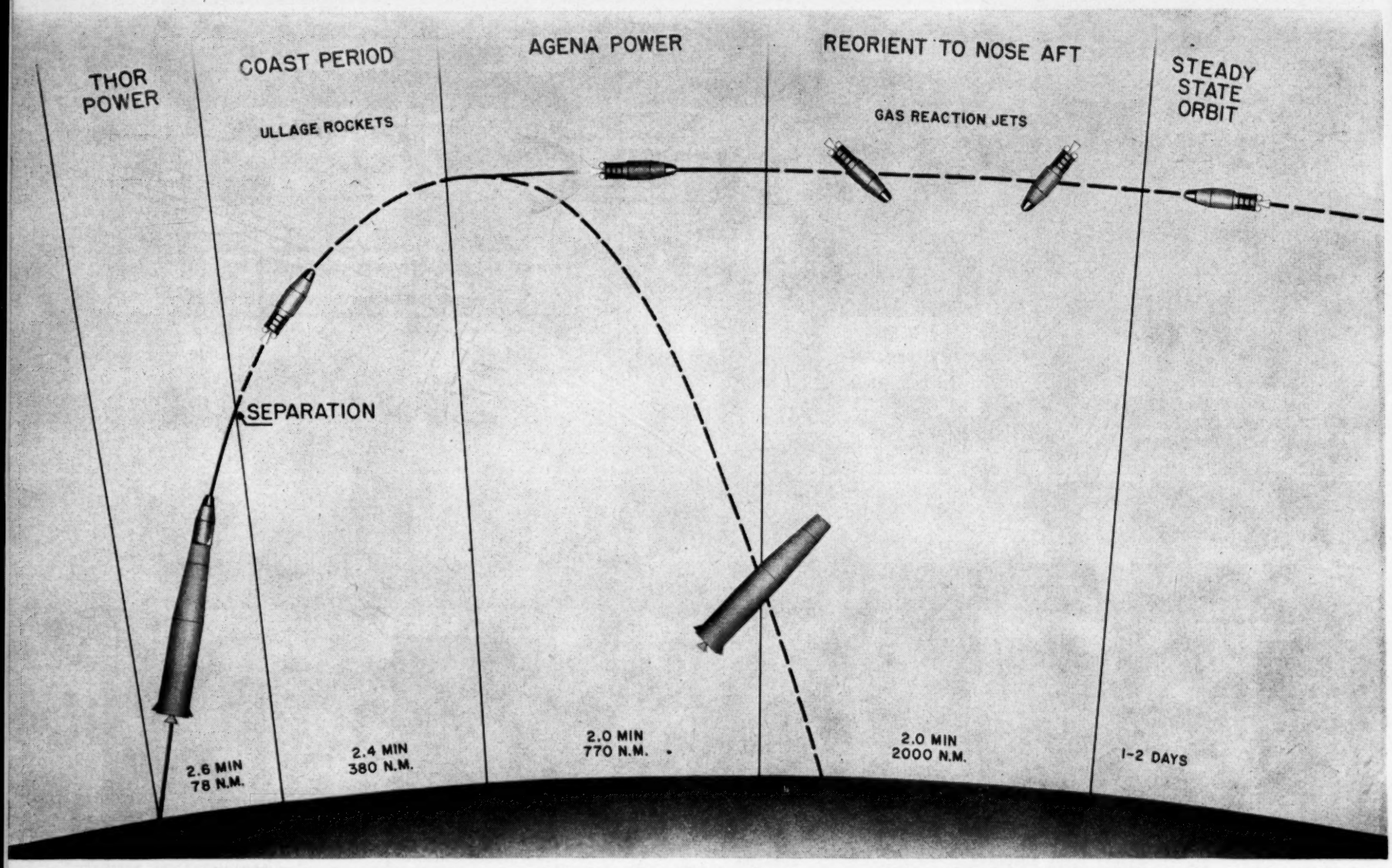


CHART SHOWS MAJOR PHASES during complete launch, orbit and recovery sequence for Discoverer satellite. Operations include

tems Command headquarters.

Gen. Estes also has a command and communication channel through which he can take top-priority problems in the ballistic and space area directly to designated Systems Management groups in USAF headquarters without going through normal Systems Command channels. He, of course, keeps Gen. Schriever informed of these moves but is authorized to act directly. The large solid booster program currently being handled under Space Systems Division is a good example of a high priority program that of necessity makes frequent use of this channel.

The Wright-Patterson AFB complex at Dayton, Ohio, has been the main center of Air Force aeronautical development since World War I and the growth of its technical laboratory complex and civilian technical personnel over the past 40 years has given it the largest percentage of in-house capability of any major Systems Command division.

For most of its history USAF was pursuing a single thread of technical development—aircraft that flew faster, higher and farther and carried heavier loads.

With the post-war addition of ballistic missiles, and complex electronic and space technologies, USAF found itself without anything remotely near the in-house capability in either officers or civilians to provide the same degree of technical evaluation or managerial ability that it had developed over the years for aeronautical systems.

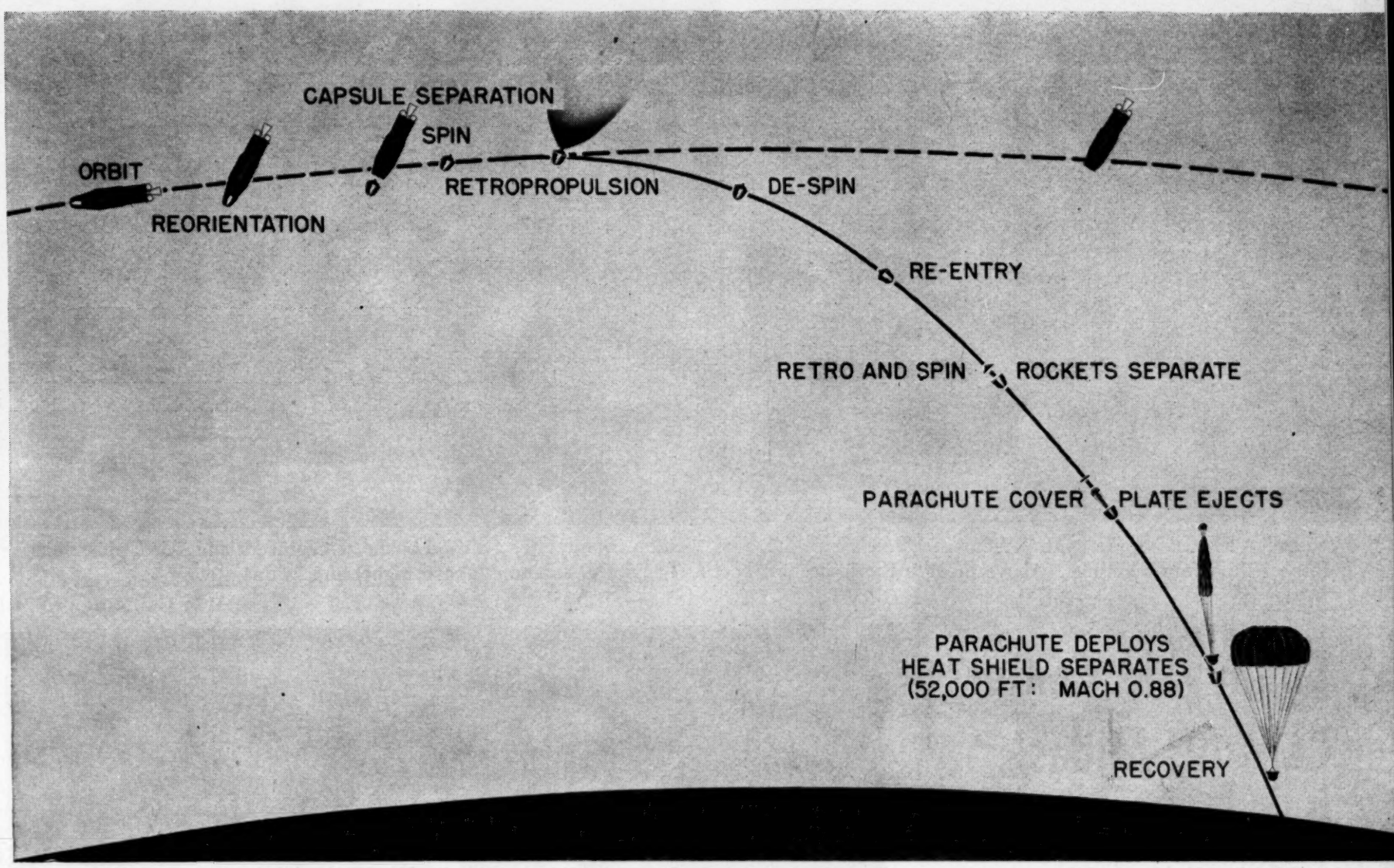
First with the ballistic missiles and later with electronics and space technology, it turned to the use of specially organized civilian corporations to help provide the technical direction and systems engineering which these new technologies and their increasingly complex weapon systems required. Space Technology Laboratories of the Thompson Ramo Wooldridge Corp. was engaged to provide this capability for the Ballistic Missile Division of ARDC, but its corporate ties with a hardware-producing contractor to USAF aroused competitive industrial ire that culminated in a congressional investigation and orders to USAF to change its procedures in this area.

Because it was already so deep in technical direction and systems engineering on the ballistic missile systems through Minuteman, STL is still used by Ballistic Systems Division of Systems Command for this purpose. However, to take over programs beyond the ICBM family, USAF organized a new nonprofit group, Aerospace Corp., to fulfill this function for the Space and Ballistic Systems Divisions on all new systems and technical areas under their control. Detailed organization and operation of Aerospace Corp. was described in a series of articles in Aviation Week (Aug. 7, p. 52 and Aug. 14, p. 66). Similarly, Mitre Corp. was reoriented to provide technical perspective and competence for the Electronic Systems Division.

Although ARDC made a major effort to develop more technically trained officers, with an elaborate program of advanced technical education in universities, the supply has never been able to keep up with the growing spread of USAF requirements through an increasingly broad portion of the technical spectrum. A steady stream of these technically-educated officers, seasoned by operating experience in ARDC and Systems Command, has flowed out of USAF into industry. Between the increasing requirements and the attrition of experienced officers in the field grades, USAF has never been able to develop much of an in-house technical capability beyond its bare minimum requirements for systems managers and development test facility operators.

Even in the test facility area ARDC and now Systems Command find it necessary to draw on industrial contractors to augment "blue suit" capability. These contractors operating Systems Command facilities include:

- **Pan American World Airways,** with a major subcontractor on instrumentation in Radio Corp. of America, to operate the Atlantic Missile Range.



launching by a Thor booster, separation, Agena power phase, capsule separation, retropropulsion, parachute deployment and recovery.

• **ARO, Inc.**, a subsidiary of Sverdrup & Parcel, to operate the test facilities at Arnold Engineering Development Center.

• **Vitro, Inc.** to operate the Gulf Missile Test Range at Eglin AFB, Fla.

Most of these contractor operations, particularly Pan American at AMR and ARO, Inc. at Arnold, have received thorough congressional scrutiny mixed with criticism. But it appears unlikely that USAF could operate these facilities as efficiently or economically with military personnel, even if they were available in sufficient quality and quantity.

Nor does it appear likely that Systems Command will be able to replace the technical functions of Aerospace Corp. and Mitre Corp. with a "blue suit" capability in the foreseeable future. More probable is the use of more specially created, non-profit corporations to fill technical gaps that may develop in the swift future expansion of USAF's areas of technical interest.

During the past five years the number of technically trained and experienced USAF officers assigned to ARDC remained about the same, despite an enormously increased requirement for them generated by the expanding scope of technology. Thus Systems Command still faces a formidable task in continuing to build up its supply of technically trained and qualified officers to staff its facilities. One of the biggest needs to bolster this area is a vastly improved USAF Institute of Technology. Top-level Systems Command officers feel the present facilities at Dayton are vastly inadequate and the curriculum should be improved to offer doctorates in technical areas.

The seven development test centers assigned to Systems Command are:

• **Flight Test Center** at Edwards AFB, Calif., which is in transition from solely a manned aircraft flight test center to a recovery area for manned space vehicles and supports substantial rocket development test facility.

• **Missile Test Center** at Patrick AFB, Fla., continues to be the primary missile and space development test range, supporting Army, Navy, and NASA projects in addition to its work for the Ballistic Systems Division.

• **Air Proving Ground** at Eglin AFB is shifting its role from operational suitability testing of aircraft and airborne missiles to a heavier role in electronic infrared and countermeasures systems. It is also developing fast as a proving ground for new tactics tailored for limited wars.

• **Arnold Engineering Development Center,** at Tullahoma, Tenn., is expanding its original role for supersonic aerodynamic and powerplant development testing into rockets missiles and space systems.

• **Special Weapons Center** at Kirtland AFB, N. M., is shifting its role from primarily a nuclear weapon test support organization and blender of bomb shapes with new aircraft and ground handling equipment, to a broader spectrum of nuclear applications to space and missile systems.

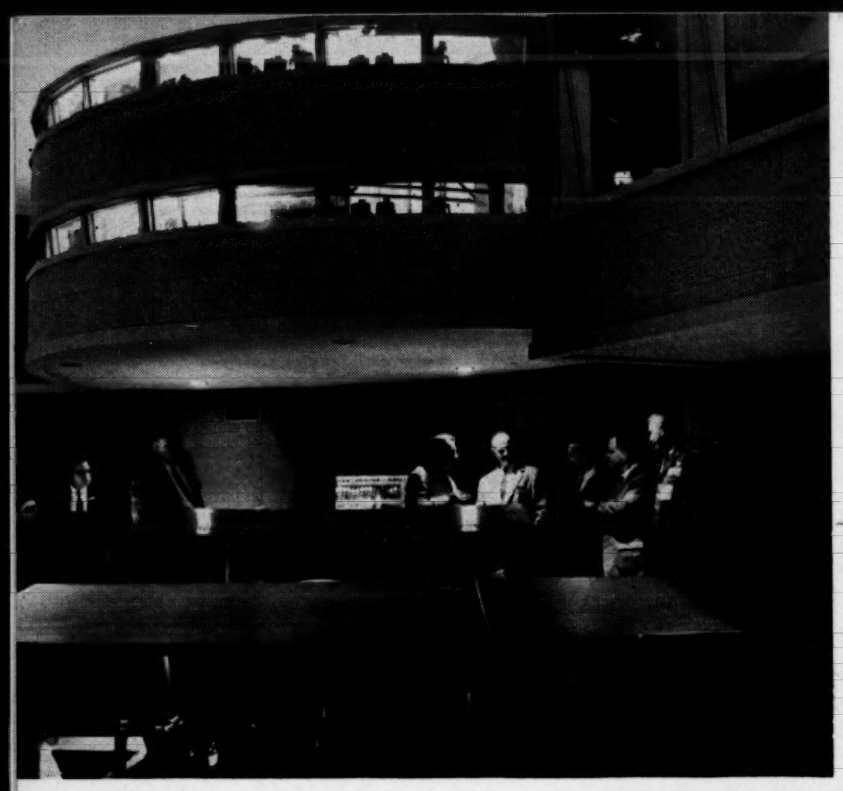
• **Missile Development Center** at Holloman AFB, N. M. Once slated to be the primary USAF space research center, Holloman is still carrying on in its variety of earlier fields, ranging from airborne missiles to bioastronautics. It is likely that Holloman will eventually be combined with Kirtland under a single command.

• **Rome Air Development Center** at Griffiss AFB, N. Y., will continue as an electronics development and test center but is assigned specifically to the control of ESD at Hanscom.

In addition to these centers, Systems Command operates other facilities including:

• **Vandenberg AFB, Calif.** Adjoining the Pacific Missile Range. Vandenberg, although a Strategic Air Command base, provides the Ballistic Systems Division with operational training configurations of each new type of missile installation and the Space Systems Division with launching sites for its polar orbiting satellites such as Discoverer, Midas and Samos.

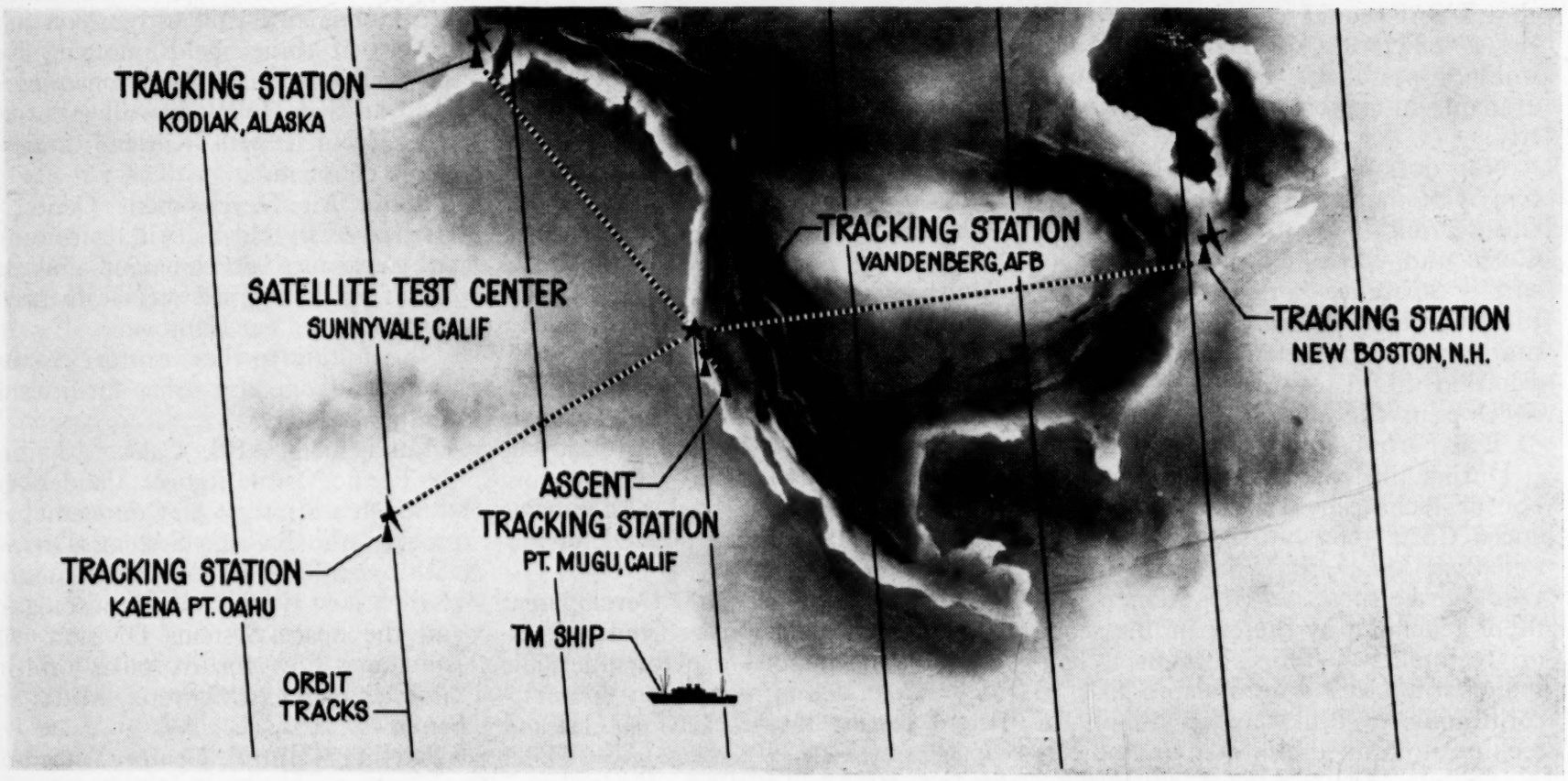
• **Satellite Control Center** at Sunny-



Standing at back of the control room in USAF's Satellite Test Center, Sunnyvale, Calif., Lockheed engineers and Air Force officers inspect the control consoles. Above them is the projection booth. Lockheed engineer (above, right) checks out a console.

Sunnyvale Center Controls Midas, Samos, Discoverer

Air Force officer (right) mans one of the eight test director consoles. Data on the orbit and payload performance of Midas, Samos and Discoverer satellites is displayed on the three 17-in. TV screens (AW Nov. 14, p. 97). Tracking data is received from various stations (below), relayed to STC for display and analysis, and commands are then issued back to the stations for transmission to the satellites.



vale, Calif. It is the nerve center for command, control and recovery operations for the polar orbiting satellite systems.

• **Norton AFB** at San Bernardino, Calif., where Ballistic Missile Division is transferring a significant portion of its activities.

• **Armed Services Technical Information Agency** in Arlington, Va. This agency acts as a central service in the Department of Defense for the interchange of scientific and technical information among the services. It also maintains liaison with other government agencies, scientific organizations and industry which collect and disseminate such information. Its principal task is to prevent duplication of effort in the services.

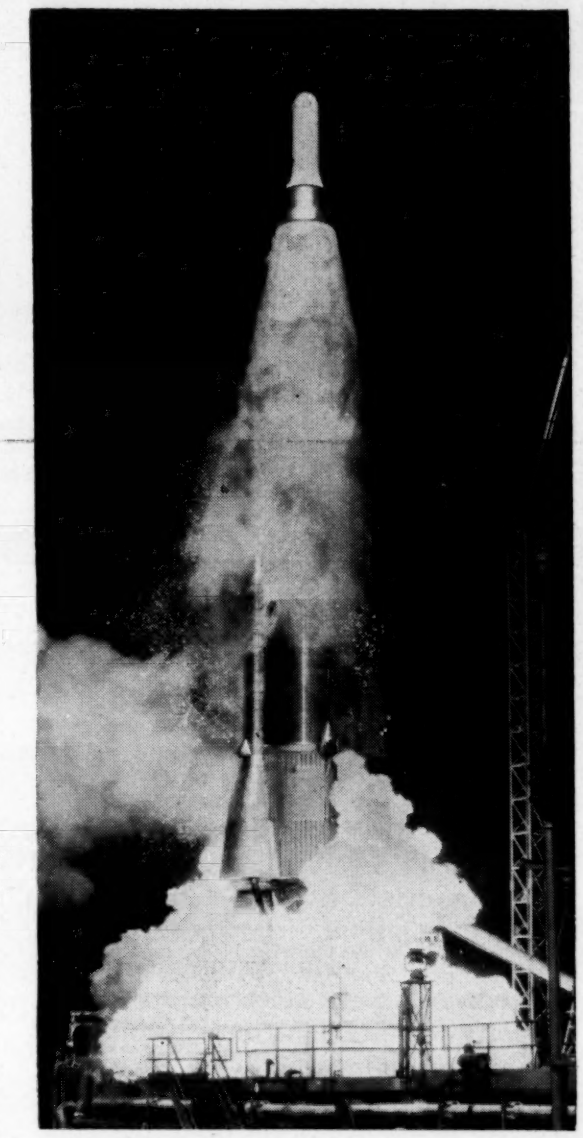
Changes Under Schriever

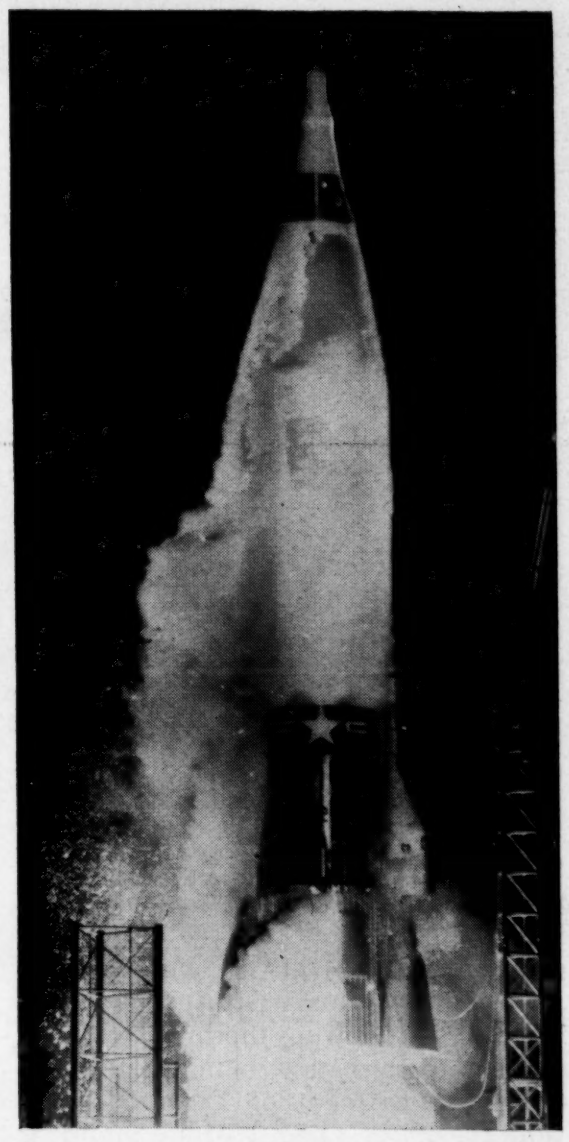
The significant change in the character and function of Systems Command headquarters began over a year before the new command was organized. During the early months of Gen. Schriever's tenure as commander of ARDC he had several groups analyze this command's management and command structure. These reports were all critical of the then existing headquarters functions, describing them as attempting to exercise too centralized and too detailed control over weapon system management and dispersing activities in too many directions.

As noted earlier, many months before the formal creation of a Systems Command, many of its basic organizational features appeared as part of an ARDC re-organization instituted by Gen. Schriever. The basic elements of this re-organization shifted weapon system management control to the System Program Directors in charge of the various weapon system program offices, located physically at the headquarters of the operating divisions.

The character of ARDC headquarters, now retained by Systems Command headquarters, changed to make it less of a centralized, decision-choking bottleneck and freed it from detailed dabbling in weapon system management and the programs operated by the divisions and supported by the centers.

At the same time, the System Program Director's role was strengthened by the issuance of the USAF 375 series of regulations that spelled out, both in their provisions and the official interpretation of them, increased authority and responsibility for the Weapon Systems Program Offices and their program directors. For the first time it enabled these program directors to plan their entire development package realistically, including resources to be allocated them from other commands concerned such as Logistics Command, the user command, training command and test centers involved. Under the new Systems Command management philosophy these program directors are allowed to run their specific programs within the resources and technical objective directives provided them without any routine interference from Systems Command headquarters. Only when a red flag indicates objectives are not being met or other crises may occur does Systems Command headquarters interject itself into the program director's operations.





LATEST VERSIONS OF THE ATLAS—Atlas F (right) and Atlas E (left)—are launched in development firings at Cape Canaveral. Atlas F has a special test mounting of the Avco Mk. 5 re-entry vehicle for Minuteman on this shot. The E version has the Avco Mk. 4, Mod. 1 re-entry vehicle.

The System Program Directors are authorized to use the "red line" procedures established by the Secretary of the Air Force to get swift, technically-sound decisions at critical phases in key weapon systems. Program director for any of the specially designated USAF weapon systems can report directly to the USAF Secretary's Designated Management System Group without going through Gen. Schriever and Systems Command headquarters. The Systems Review Board of the Air Staff adds its input to any problem going through this channel to the Designated Systems Group but has no power of decision. The Designated Systems Management Group consists of a mixture of top-level civilian secretariat and military personnel including Gen. Schriever.

Systems Command headquarters consisted of 1,150 military and civilian personnel in its former ARDC role and has added about 150 people, primarily from the old Air Materiel Command procurement division at Wright-Patterson AFB. Over-all, the command acquired 45,200 people from ARDC and 15,000 from AMC.

Headquarters is now organized around seven deputy chiefs of staff reporting to Gen. Schriever through the vice commander, Maj. Gen. James Ferguson. They are:

• **DCS Systems.** Recommends policies and procedures for systems program management, test and evaluation. He is the focal point on the staff for management. This latter function is modified somewhat for the Ballistic Systems and Space Systems Divisions as described later. Two assistants are assigned for systems management and international programs. There are directors for engineering, systems test, aeronautical systems, ballistic missile and satellite systems and electronic warfare.

• **DCS Research and Engineering.** Recommends policy concerning applied research, and advanced tech-

nology and is the contact point for the AFSC staff with the Office for Aerospace Research, the National Science Foundation and other official and private scientific bodies and individuals. He has one assistant for policy and procedures. He is also assigned directors for research, advanced development and also for scientific liaison.

• **DCS Plans.** Responsible for guidance and goals for basic and applied research. Guides and conducts the AFSC study programs and recommends the establishment of advanced development projects and new operational systems. These recommendations are sent to Air Force headquarters to aid in the generation of military requirements. Plans are also directed at assuring the continued capability of the command to accomplish its mission. Under DCS Plans are a policy office, an assistant for advanced methodology and directorates for development planning, resources and analysis.

• **DCS Comptroller.** This is the single financial manager for the command combining both the costing and programing functions in this shop. This is aimed at following the financial management pattern now being established in the Department of Defense comptroller's office. The costing group is specifically charged with developing a better capability for more realistic cost estimating of the development programs.

• **DCS Personnel.** Responsible for manpower and organization policies for the commander. These are assistants for control of senior officer assignment and for reserve affairs. Directorates include military personnel, personnel programs and training, personnel research and long-range plans, personnel services, civilian personnel and manpower and organization.

• **DCS Procurement and Materiel.** Exercises staff and management control over all functions related to procurement for all elements of the command. It is the headquarters staff agency for the Contract Management Regions. He is assigned two assistants for materiel policy and technical services and directors of materiel support, civil engineering and procurement.

• **DCS Foreign Technology.** Directs the Foreign Technology Program for the commander. There are two directors, one of foreign activities and special applications and one of foreign technical analysis reporting to him.

As it begins operations under its new authority, Systems Command leaders see three main areas that require major improvement.

These areas are:

• **Management.** This is a broad area to which top-level Systems Command headquarters is planning to devote major effort. This effort will be aimed at developing more efficient procedures in dealing with industry in the new procurement areas transferred to Systems Command. It will be aimed at insisting on more realistic technical and cost proposals from industry, better methods of source selection for major weapon system design competitions and exploration of methods to introduce sharper competition from industry, particularly below the level of prime contractors through major subsystem developers.

Better post-contract management procedures and better contracting methods are also prime targets for improvement in this area.

A special management survey office has been created in Systems Command headquarters reporting directly to Gen. Schriever. This group is aimed at giving the command the capability to inspect and analyze specific programs where problems appear with a view toward recommending management solutions.

Another major managerial change to be sought by Systems Command is improvement in the stability of its top-level policy decisions in an effort to replace short-term vacillations with solid long-range planning policies.

• **Development Planning.** Improvement in this area is necessary to achieve the stability of top-level policy decisions required. Systems Command headquarters plans to devote considerably more effort to this function in an effort to attune its long-range planning for development of future military weapon systems better to the future trends of fast moving technology. There is a feeling in Systems Command that military planning has not been sufficiently realistic in taking into account the widening range of future technology and of taking too short-term a view in trying to crank future technical possibilities into future weapons requirement planning.

Pressure Building

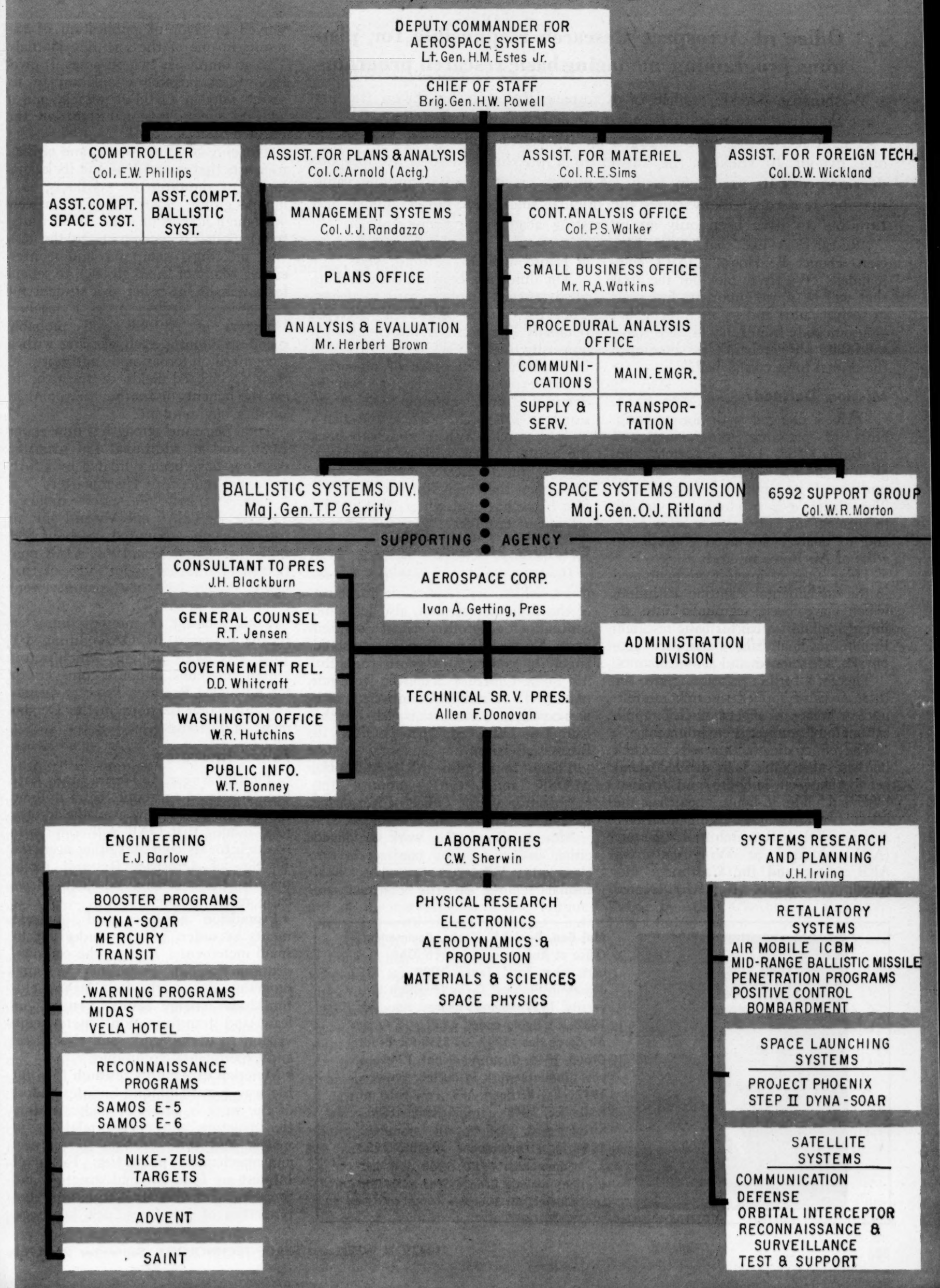
There is already considerable pressure on all military services, including Systems Command, from Congress and Department of Defense to develop better methods of realistically costing a development program, and this fact will be reflected in its dealing with industry. Systems Command warns that the days of low-priced initial development proposals from industry merely to get a foot in the door are over and that it intends to analyze costs for a complete development program from its inception. It also plans to rate industrial contractors according to the accuracy of their cost proposals.

• **Personnel.** Although a USAF career in research and development has become more attractive during the past decade of technological growth, Systems Command faces a major problem in training sufficient younger officers to meet its expanding requirements for "blue suit" capability in systems manager, development and test programs and also to retain these personnel within the command in the face of lures offered by private industry. Systems Command does not intend to alter its basic dependence on industry for the bulk of its research and development effort, but it faces an urgent requirement to develop more technically educated personnel to handle its increasing load in testing, evaluating, analyzing and managing the programs it contracts to industry for execution.

Systems Command has been charged with a formidable responsibility. It has been given the basic resources and authority its leaders feel are required and it now faces the task of producing the combat-ready new weapon systems of qualitative superiority in time to make them militarily significant for the future of this nation and its allies.

Lt. Gen. Howell M. Estes, Jr., Deputy Commander for Aerospace Systems, AFSC . . . born Fort Oglethorpe, Ga., 1914 . . . graduate U. S. Military Academy, 1936 . . . learned to fly, 1940 . . . served with USAFE 1946 to 1948 . . . Air War College . . . 22nd Bomb Wing in U. S. and United Kingdom . . . commanded First Air Base Group, 44th Bomb Wing . . . vice commander, FEAF Bomber Command . . . 25 combat missions in B-29s over Korea . . . commanded 106th Bomb Wing, the 12th Air Division and Air Task Group 7.4 . . . Director of Weapon Systems Operations, ARDC, 1954 . . . Assistant Chief of Staff, Air Defense Systems, 1957, Assistant DSC/Operations, USAF 1958.

AFSC Aerospace Systems Organization



USAF Sifts Advanced Research Concepts

Office of Aerospace Research responsible for planning, programing, managing basic research programs.

Washington—USAF's Office of Aerospace Research has taken the first steps along the long road that leads to operational weapon systems.

A contract for research costing a few thousand dollars may turn up in one, five or 10 years as the answer to a puzzling question in weapons development. Its payoff, in terms of money saved or an intangible value, may be assessed at many times the original small investment. Or it may turn out to have been only an interesting academic exercise.

"Research is like that," said Maj. Gen. Daniel E. Hooks, OAR's commander. "We try to pick out the areas that will be most important five years or so from now and go after them, but —as somebody from Lincoln Labs said— solid-state physics hasn't yet developed the crystal for a crystal ball."

Mission Defined

OAR is charged with the responsibility of planning, programing and managing the basic research program of the Air Force, plus an assigned portion of its applied research work. The objective is two-fold: To increase the general store of scientific knowledge, and to analyze advanced concepts in areas of Air Force interest.

These areas of interest are contained in the fundamental scientific disciplines which have been regrouped into six interdisciplinary areas for basic research: Propulsion, materials, electronics, geophysics, life sciences and aeromechanics.

There is a further regrouping into the three areas of applied research interest: nuclear weapons effects, nuclear applications and aerospace environment.

The effort directed towards research in these nine subjects is divided about evenly between in-house and contractual work. The in-house research is the job of two OAR research organizations: Aeronautical Research Laboratory (ARL), located at Wright-Patterson AFB, Ohio, and the Cambridge Research Laboratories (AFCRL), located at Hanscom Field, Bedford, Mass.

The difference between basic and applied research is often hard to define. The Air Force draws a different boundary line between the two than a university might. "We're not interested in research for the sake of research," Hooks explains. "Maybe one way to define it is by an example. We do research in solid-state physics, and that's basic research. When somebody uses the results of that work in a transistor, that's applied research by our terms. And when that transistor becomes part of a black box somewhere, that's a development task."

Corollary Effort

Hooks pointed out that the laboratories, which are responsible for most of the in-house research, also let some contracts for corollary effort to their own. Non-corollary effort is sponsored largely by contracts or grants from the Air Force Office of Scientific Research (AFOSR). A smaller number of such non-corollary contracts is let by the European Office of OAR (EOAR) in Brussels, Belgium.

These four units—ARL, AFCRL, AFOSR and EOAR—comprise the organization of the Office of Aerospace Research.

Almost all of the work produced either in-house or by contract is unclassified. Wherever possible, final formal reports on the contract are waived in favor of publication of the results in one of the scientific journals. This accomplishes two purposes: It gives the widest possible circulation to research work in a field of interest, and it adds to the professional status of the researcher.

The elite corps of military and civilian scientists that mans OAR and its laboratories, or monitors its contracts, is a mobile group. They travel extensively —although here as in some AFSC units, travel money is inadequate to the task —to meetings, symposia and conferences. Many of them go back to school for a year or so, either as a student for an advanced degree, or as a teacher. Directors of AFOSR will probably spend six months each working with a recognized international authority in their specialized fields of research, to get the benefits of another viewpoint in another environment.

Total personnel strength is now about 1,650, and an additional 150 scientific positions have been validated by USAF personnel officers in Headquarters.

The so-called "800-series" money—allocated by USAF entirely and only to basic research—amounted to about $44 million in Fiscal Year 1961. OAR contracted or directed about 90% of that figure. About 10% of the money went to agencies in AFSC.

Total amount of money contracted for or managed by OAR during FY 1961 was $128 million, which represented programs in-house, plus efforts for Advanced Research Projects Agency and other organizations in the Department of Defense.

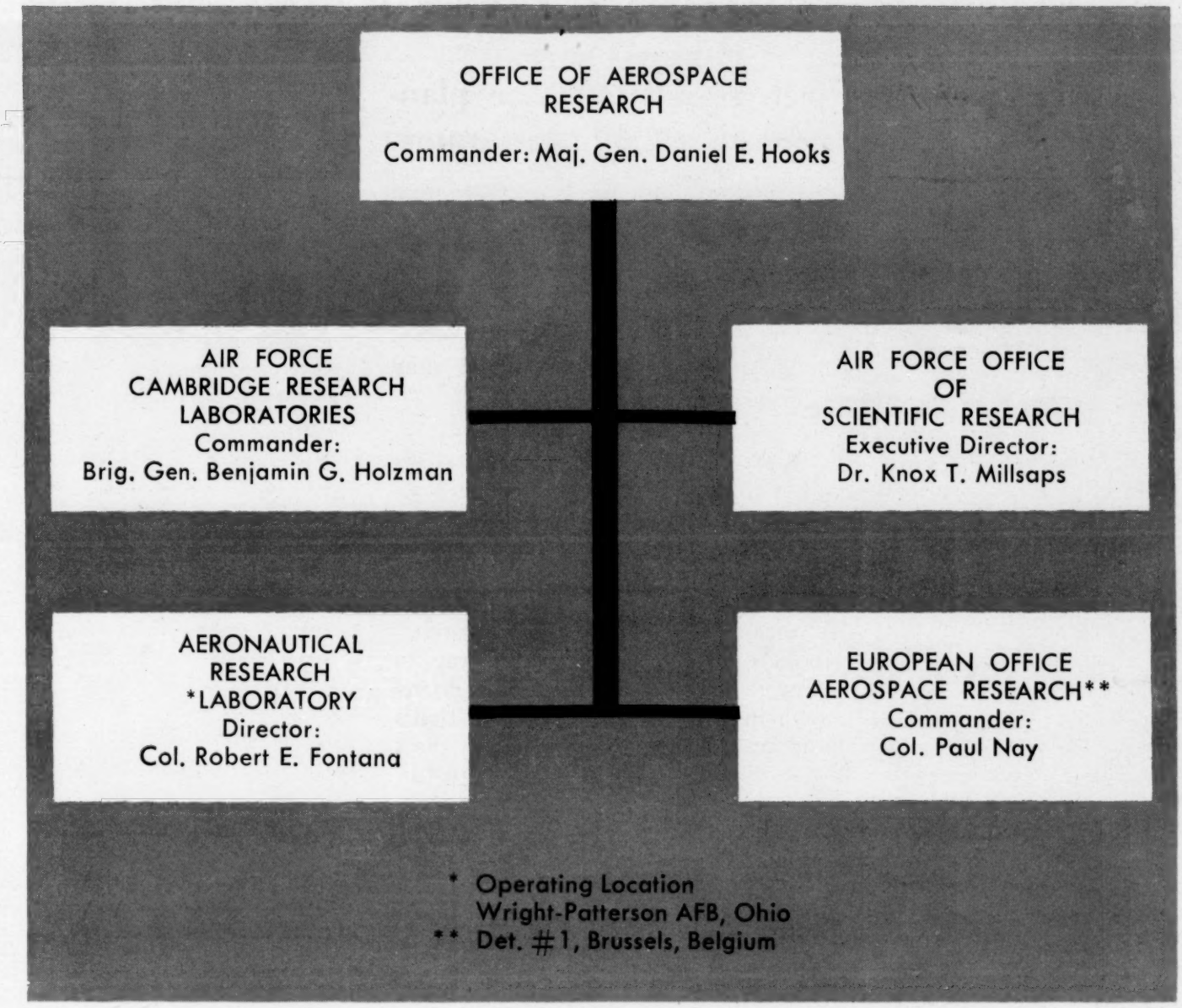
Funds Increased

This fiscal year, 800-series funds have been increased to about $50.5 million; there is no figure now available for the total money that OAR will commit to research for its own and other agencies.

Office of Aerospace Research works towards these generalized goals in its basic research program:

- **Propulsion advances** and improvements by orders of magnitude, not by small increments. Energy, the common denominator of propulsion research programs, defines the four major fields for study: energy sources, energy release and transformation, energy conversion to useful work, and theoretical and experimental techniques.
- **Materials exploratory research** to point the way toward unique findings. Most of the work is aimed at understanding the structure and energy relations in matter and their relation to physical and mechanical properties. Fields of interest are four: internal structure and properties of matter; structure and properties of interfaces; new synthetic

Maj Gen. Daniel E. Hooks, Commander, Office of Aerospace Research (OAR) . . . born Iowa Park, Texas, 1908 . . . BS degree in Physics, Texas Christian University, 1929, Masters degree, Harvard, 1932 . . . flying cadet, 1932 . . . Army Air Corps Hqs., 1942 . . . 55th Air Depot Group, 1944; Guam Air Depot, 1944 . . . post-graduate work in nuclear physics, 1947 . . . Kirtland AFB . . . chief of R&D, AEC, 1948 . . . DCS/R&D, AFSWC, Kirtland AFB, 1950 . . . Air Force Hqs., 1954 . . . Commander, AFMDC, 1958 . . . Commander AFRD, 1960 . . . decorations include Bronze Star with Oak Leaf Cluster, Air Medal.



methods; theoretical and experimental techniques.

• **Electronic technologies** which are new and fundamental rather than extrapolations of contemporary types. Here again there are four areas of interest: particle physics, interaction of fields and matter, transfer of electromagnetic energy, and information complexes.

• **Geophysics of terrestrial,** solar and universal phenomena to establish foundations for future technical development. The work is aimed at understanding the chemical and physical processes contributing to the environment of earth and near space. There are five areas here: planetary studies, the lower atmosphere, the upper atmosphere, space environment, and experimental and theoretical techniques.

• **Life sciences for a broader base** of fundamental knowledge of man's role in the USAF. This branch supports work in all the biological disciplines, as well as interdisciplinary areas to get the inputs of physical sciences. The attempt is to evolve new concepts and theories and to apply quantitative values to the experimental results. The list of areas here has not yet been exhausted; but some typical ones include molecular and cellular biology, biological organization, integrative and regulatory functions, and individual and group performance and behavior.

• **Aeromechanics problem solutions,** both old and new. Classical aerodynamics has been outmoded in many instances, replaced by many new or diverse scientific disciplines. There are three major areas of interest: properties of the flow field, mechanics of flight, and experimental and theoretical techniques.

Additional Objectives

In addition to these, there are three specific applied research objectives which have been assigned to the Office:

• **Nuclear weapons effects.** Object of this research is to learn about the output of nuclear explosions, the output interaction with the environment, and the response, protection and recovery of targets such as humans.

• **Nuclear applications.** Aim of this phase is to learn how to integrate nuclear weapons into USAF weapon systems with increased safety and reliability. This work also includes improvement and development of instrumentation, plus capability studies of current and future weapon systems.

• **Aerospace environment.** The atmosphere and space come under this task for detailed study to acquire better knowledge of the USAF's operating environment. Among the studies are physical and chemical composition of the atmosphere, auroral and ionospheric physics, gravitational and magnetic force fields, geodesy, meteorology, photochemistry, solar-terrestrial effects and space physics.

These three areas of applied research are handled both in and out of OAR. Weapons effects, for example, are very obviously the specialties of Air Force Special Weapons Center of Systems Command. Additional capability in that field is held by Aeronautical Systems Division. These two AFSC units work in coordination with AFCRL in determination of weapon effects.

In contrast, all of the aerospace environmental work is done at or monitored by the Cambridge Research Laboratories, which include the Geophysics Research Directorate at Hanscom Field. Probe rockets and high-altitude balloons, including a detachment stationed at the Air Force Missile Development Center, Holloman AFB, N. M., also come under this work at CRL.

An interface between the USAF and the scientific community is provided by the Air Force Office of Scientific Research, whose executive director is Dr. Knox Millsaps.

AFOSR is the first point of contact between the Air Force and a scientist anywhere in the United States or the rest of the world outside of the area serviced by EOAR in Brussels. This discipline-oriented organization, co-

REPORT FROM SPACE

A-OK *via Project Mercury*
Ground Instrumentation Stations

Congratulations to the National Aeronautics and Space Administration on the first orbital space flight of the Mercury spacecraft. We at Bendix-Pacific are justly proud of the successful functioning of our telemetry systems designed and built for the 18 world-wide stations as a member of the Western Electric team. These stations — the vital link during flight — receive, record and display the physiological, environmental and other physical data transmitted from the capsule.

Bendix-Pacific Division
NORTH HOLLYWOOD, CALIFORNIA

Circle Number 84 on Reader-Service Card

located with OAR for economy, is wholly concerned with the support of basic research grants and contracts. More formally, it plans, procures and manages a contract- and grant-supported program of fundamental research in areas of special interest to the Air Force.

Millsaps' office is also responsible for interpreting the results and implications of research as they pertain to future operational weapons systems.

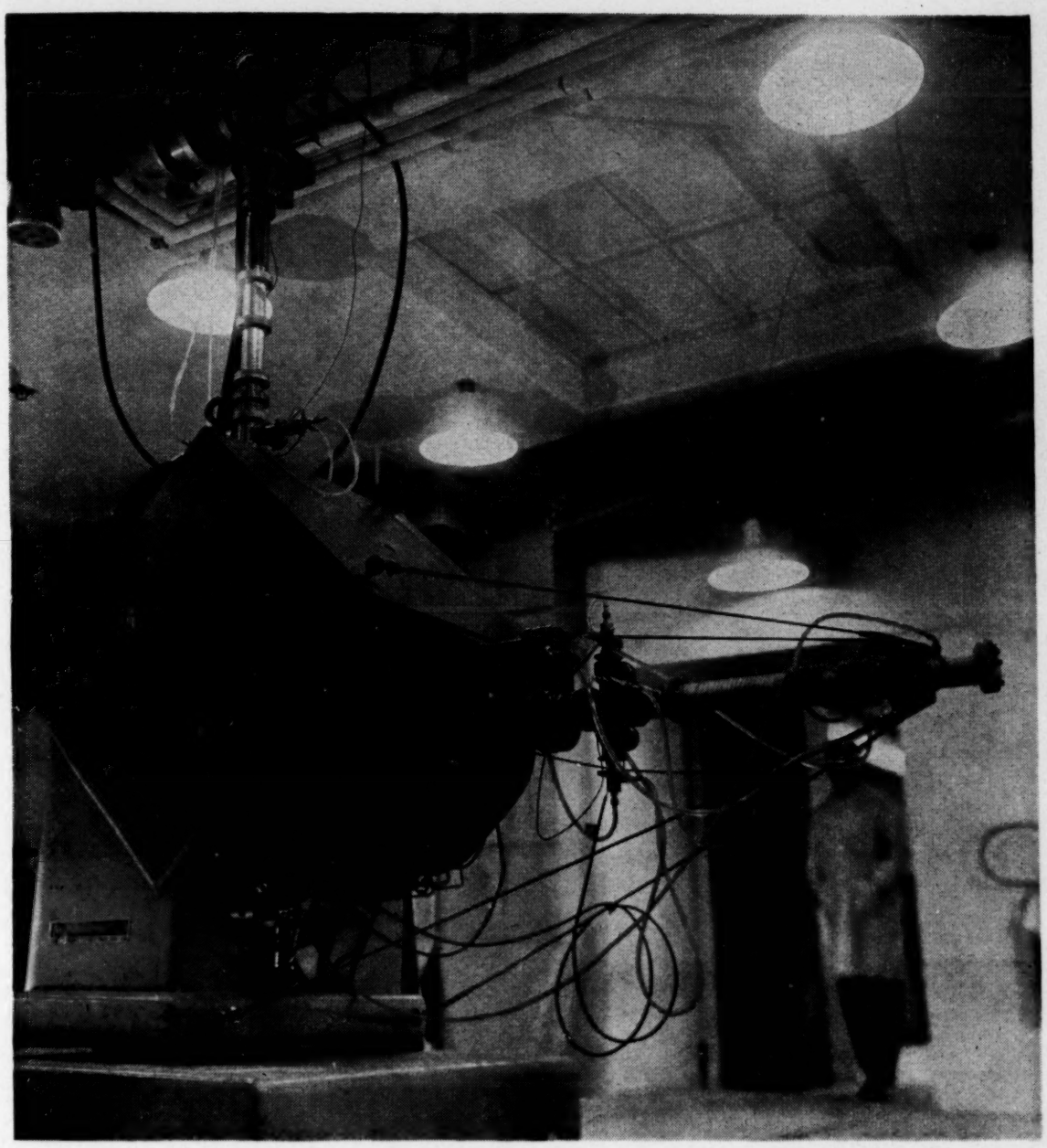
The approach to AFOSR starts in an idea for research, outlined by a scientist to the Office, either verbally during a discussion, or in writing. "We've even gotten them on postcards," said Millsaps.

His rough outline is considered by Millsaps, his directors or project monitors, depending on the depth of the initial report. If on first assessment the idea looks good, the scientist will be asked to elaborate in a letter or by personal discussion with the scientists in AFOSR.

This is not yet a formal proposal, Millsaps says, but it is aimed at providing enough information about the project to decide whether or not it should be financed by the Office.

The decision to investigate the project further may actually be made by one of the AFOSR staff, from Millsaps down, or from one of AFOSR's seven advisory committees, groups of 10 to 15 top scientists outside the Air Force who are available for just such decisions and consulting as this. Then the scientist is invited to submit a formal proposal for sponsorship of his research.

That proposal will be evaluated by an advisory committee, which will be used only to get its reactions to the merit of the idea, and not to approve or reject the project. That prerogative is held by AFOSR.



THREE-MEV. VAN DE GRAFF GENERATOR AT AFCRL

Contracts or Grants

Funding may be by either contract or grant, with the exception that grants may not be used to finance scientists working for industry or as individuals. Millsaps prefers grants to contracts; out of the first 64 investigations that AFOSR awarded this year, 59 were grants.

"For one thing, the regulations for administration of contracts weigh nineteen pounds," Millsaps explained, "And those for grants weigh three ounces. A contract has many pages, but the grant document and its financial report are one page each."

There are other problems. A grant is paid instantly and is money in the bank coincident with the start of research. Contractual funds may take longer to process, and the recipient may have to borrow the money to get started to meet his deadline date. Interest charges on money borrowed like that are not reimbursable under the terms of the contract.

Grants are made in the names of the principal investigator to universities, research institutes, nonprofit organizations and the like on the basis that they represent money paid for the services of an individual. The actual money is handled by facility accounting services, not the principal investigator.

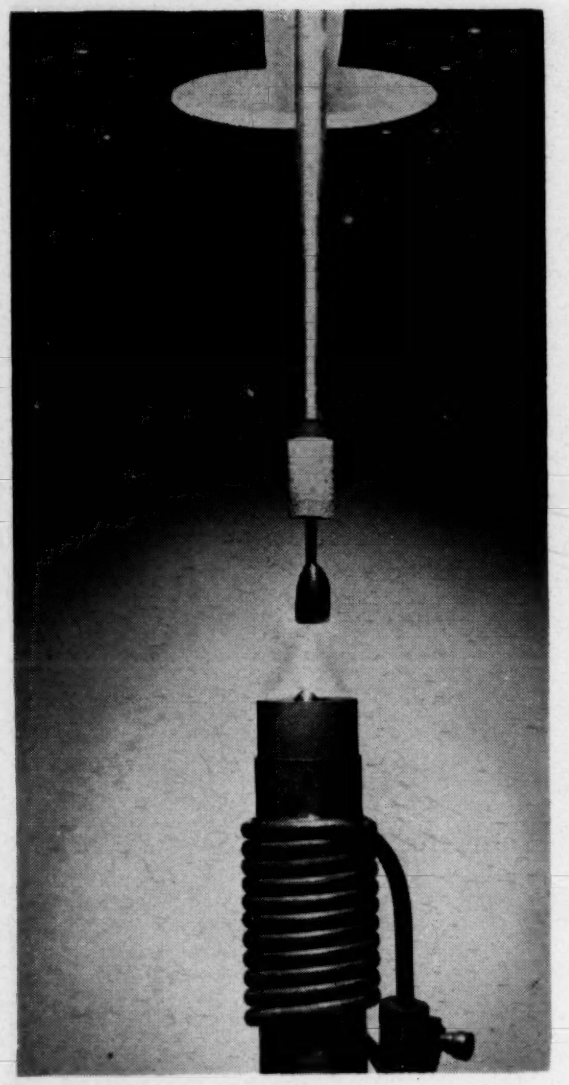
"We want to get the government out of the publishing business," said Millsaps. "We encourage the author to publish his results in one of the scientific journals, and we'll accept reprints from the journal as final reporting on the research."

There are currently about 1,100 active research contracts and grants which have been awarded to scientists throughout the world. They include work in almost every one of the United States, plus a number distributed over the free world and ranging in quantity from the high of New York State's 138 contracts to Ghana's one. Total value of all the contracts is about $100 million, a sum above the allocated funds for Air Force basic research because other money comes in from agencies such as ARPA for research which AFOSR will then manage for the agency.

Millsaps says he uses "thermodynamic management"—a self-named technique where the manager is only concerned with the initial state and the final state and doesn't worry about the machinations in between. He points to an overhead rate of approximately 3% —the current figure for AFOSR—which it contributes to the over-all cost of managing the contracts and the grants.

Millsaps heads a staff of about 150 people, which includes 29 geographically stationed at Holloman AFB, N. M., in the Air Force Missile Development Center. There are seven directorates in AFOSR: Engineering Sciences, Life Sciences, Mathematical Sciences, Physical Sciences, Chemical Sciences, Research Analysis, and Procurement.

One of these—the Directorate of Research Analysis—is unique. It consists of a group of scientists, many of whom formerly worked in Germany at research institutes and universities during World War II. These scientists, part of the Operation Paperclip teams that were brought to the United States toward the end of the war, originally were organized into this research analysis team when Millsaps was Chief Scientist of the Air Force Missile Development



GROWING ALUMINUM OXIDE CRYSTAL

Center, under the former Air Research and Development Command. When the word got out that Millsaps was to be transferred to Washington, the team let it be known that it wanted to work for him wherever he went. It was moved under the operational organization of AFOSR one year ago when Millsaps made the move to Washington, but it remains located at Holloman AFB.

The work of the Directorate of Research Analysis is done mostly for AFSC, and it involves realistic studies and analyses of operational problems. Typical examples are a missile-interception study, and an economic analysis plus engineering study of the cost of pounds in orbit, delivered by varieties of schemes now in conceptual form.

Millsaps says he's doubly fortunate to have scientifically trained officers on the staff who have served operational tours of duty with operational commands. "They know the problems at one end of the scale, and they come here and help us while we educate them about the other end of the problem," he said.

But interchange in the other direction still stumps him. He'd like to transfer civilians out to the operational commands, although he admits he hasn't yet found a way to do this. "Maybe we could lend them to operations analysis units in Strategic Air Command," he mused.

Under the early organization of the Air Research and Development Command, a headquarters staff section designated as the Office of Scientific Research managed contract research and supervised ARDC's in-house research.

Independent Center

Late in July 1955, it was reconstituted as an independent center called the Air Force Office of Scientific Research. Its job was changed; only contract research came under its control. A separate Directorate of Research on ARDC's staff took over all responsibility for the Command's basic research activity, both contract and in-house.

The over-all ARDC reorganization early in January 1960 established the Air Force Research Division in Washington, D. C., with the responsibility for supervising USAF basic research and some assigned applied research as well. This is essentially the same mission OAR has today.

Originally AFRD was composed of two units: AFOSR, which was by then also located in Washington, and the European Office of ARDC in Brussels. Later in the spring of 1960, AFRD assumed operational control of the Aeronautical Research Laboratory at Wright-Patterson AFB, and what is now called the Air Force Cambridge Research Laboratories at Bedford, Mass.

REFLECTOR CARRIED IN BALLOON

ARDC was reorganized in April this year, picking up agencies and redirecting its mission to become the Air Force Systems Command. At the same time, the Office of Aerospace Research was established as a separate agency, no longer under ARDC, but directly responsible to Headquarters, USAF.

Air Force Office of Scientific Research

Contracts within the United States

Alabama	6	Kentucky	1	Ohio	34
Arizona	4	Maine	1	Oklahoma	9
Arkansas	3	Maryland	41	Oregon	6
California	133	Massachusetts	73	Pennsylvania	64
Colorado	9	Michigan	29	Rhode Island	15
Connecticut	14	Minnesota	28	South Carolina	3
Delaware	4	Missouri	15	Tennessee	1
Dist. of Col.	32	Nebraska	1	Texas	17
Florida	18	New Hampshire	6	Utah	6
Georgia	5	New Jersey	47	Vermont	1
Illinois	78	New Mexico	5	Virginia	13
Indiana	17	New York	138	Washington	2
Iowa	4	N. Carolina	12	Wisconsin	11
Kansas	7	North Dakota	1		

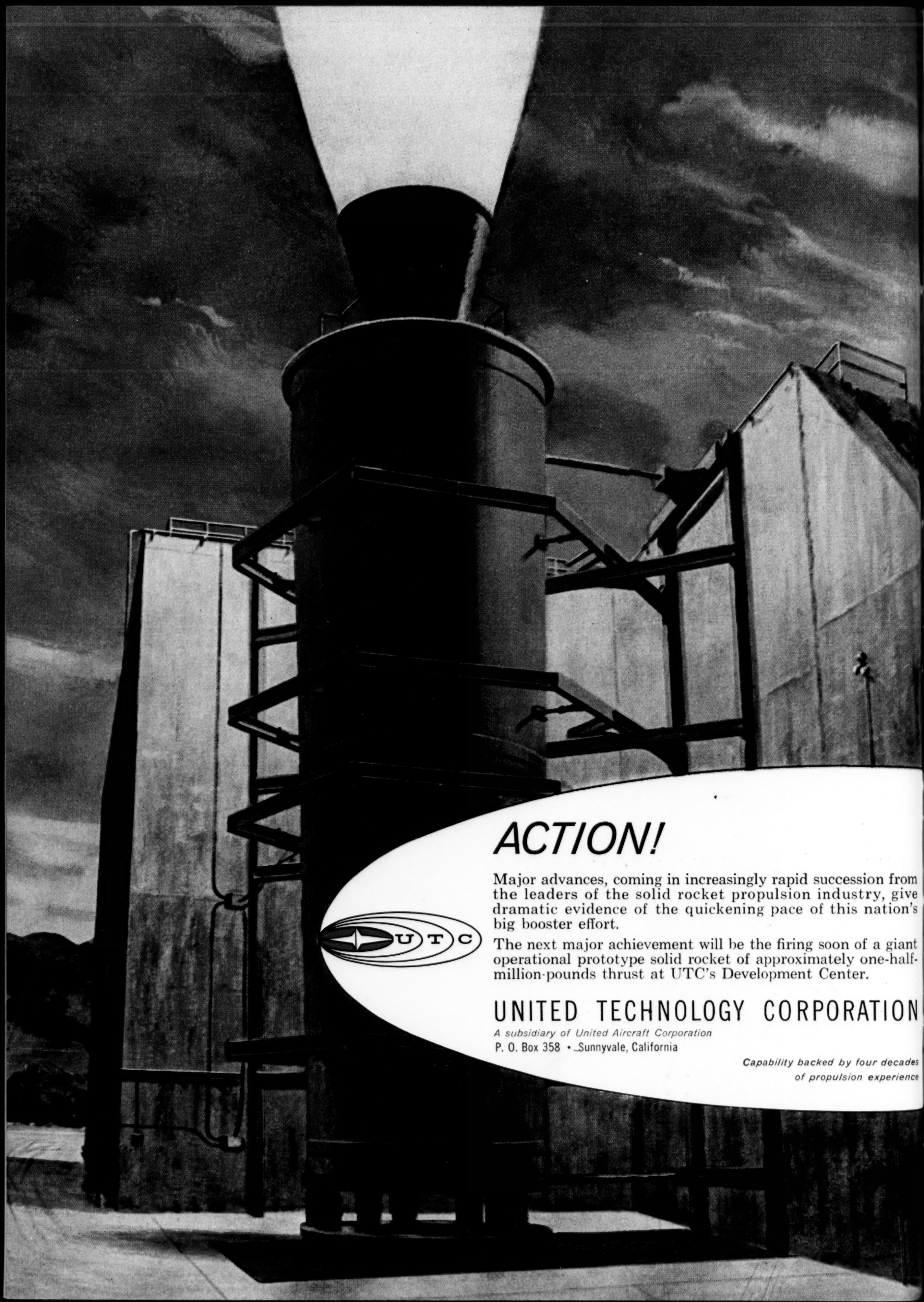
Contracts outside the United States

CANADA	15	EUROPE	
SOUTH AMERICA		Austria	4
Argentina	3	Belgium	12
Bolivia	1	Denmark	4
Brazil	10	France	20
Chile	5	Germany	21
Peru	2	Gt. Britain	54
Uruguay	3	Italy	24
AFRICA		Netherlands	2
Ghana	1	Norway	5
AUSTRALIA	2	Spain	5
MIDDLE EAST		Sweden	29
Israel	24	Switzerland	2
Turkey	2	PUERTO RICO	1

Status as of June 30, 1961

USAF DISCOVERER XXVI snatched from air over Pacific Missile Range.

Space Systems



ACTION!

Major advances, coming in increasingly rapid succession from the leaders of the solid rocket propulsion industry, give dramatic evidence of the quickening pace of this nation's big booster effort.

The next major achievement will be the firing soon of a giant operational prototype solid rocket of approximately one-half-million-pounds thrust at UTC's Development Center.

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AF Space Management Tasks Centralized

Space Systems Division mission combines applied research and systems development procedures.

Los Angeles—Creation of the Space Systems Division has given the Air Force a centralized top management echelon designed to exploit the full spectrum of the nation's space technology, and to apply this technology to the expanding military requirement for satellites, other types of space vehicles and the boosters that will launch them.

Space Systems Division brings applied research, advanced development and systems development together. The results are represented by integrated hardware tests and demonstrations of systems on which the Air Force will base its operational space vehicles of the future.

Appearance of this division is clear recognition that the technical explosion of the past decade has spawned an Air Force with a new look and re-directed goals. SSD eventually may be the greatest consumer of fundamental technology in the U. S. research program, and the new division must face this responsibility by quickly and effectively translating concepts into research, and research into hardware.

Commanded by Maj. Gen. Osmond J. Ritland, SSD has forces in the Los Angeles complex, Sunnyvale, Edwards AFB and Vandenberg AFB. But division support is not isolated in these locations—every element of the USAF Systems Command is involved in SSD projects, from sounding rocket experiments at the Eglin Gulf Test Range to full-scale satellite launches from the Atlantic Missile Range.

Nucleus of SSD came from Air Research and Development Command's Ballistic Missile Division, which Gen. Ritland commanded and from the old Air Materiel Command's Ballistic Missile Center, particularly from the directorate of space and satellites. The organization was expanded greatly in stature and in people, and is much more than a new division splintered from an old.

In the reorganization of Air Research and Development Command, space was given an equal status with ballistic missiles, and both were organized under AFSC's Deputy for Aerospace Systems, Lt. Gen. Howell M. Estes. Missiles, eventually, can be expected to decrease in types under development while space system development is certain to expand. When the manned military space vehicle requirement is firmly defined, it will be SSD which will take the requirement from a definition to hardware.

The responsibility contains an inherent need for a flexible organization able to withstand continued growth in the capability to manage, and to be responsive to the revolutionary and evolutionary products of the technical fruits maturing from space technology research.

SSD sees its immediate mandate contained in two directives. The first, issued Mar. 6 by Defense Secretary Robert S. McNamara, assigned development of military space systems, with a few exceptions, to the Air Force. The second, announced May 25 by President Kennedy, assigned the Air Force the responsibility for developing the Nova solid propellant booster motor.

The McNamara directive gave the Air Force, and in turn SSD, all space developments except Transit, which is being managed by the Navy, and Advent, an Army project. Project Anna is a joint Army-Navy-National Aeronautics and Space Administration-USAF venture. Transit is a navigation satellite; Advent an active communications satellite designed to orbit synchronously around the equator, and Anna, a geodetic satellite. SSD is deeply involved in all these projects, however, since it procures and launches the vehicles which take the satellites into orbit.

President Kennedy's Nova directive was much more than assignment of a project. It broke a two-year moratorium, unsatisfactory to both NASA and the military, which prohibited any hardware work on large boosters by the Defense Department.

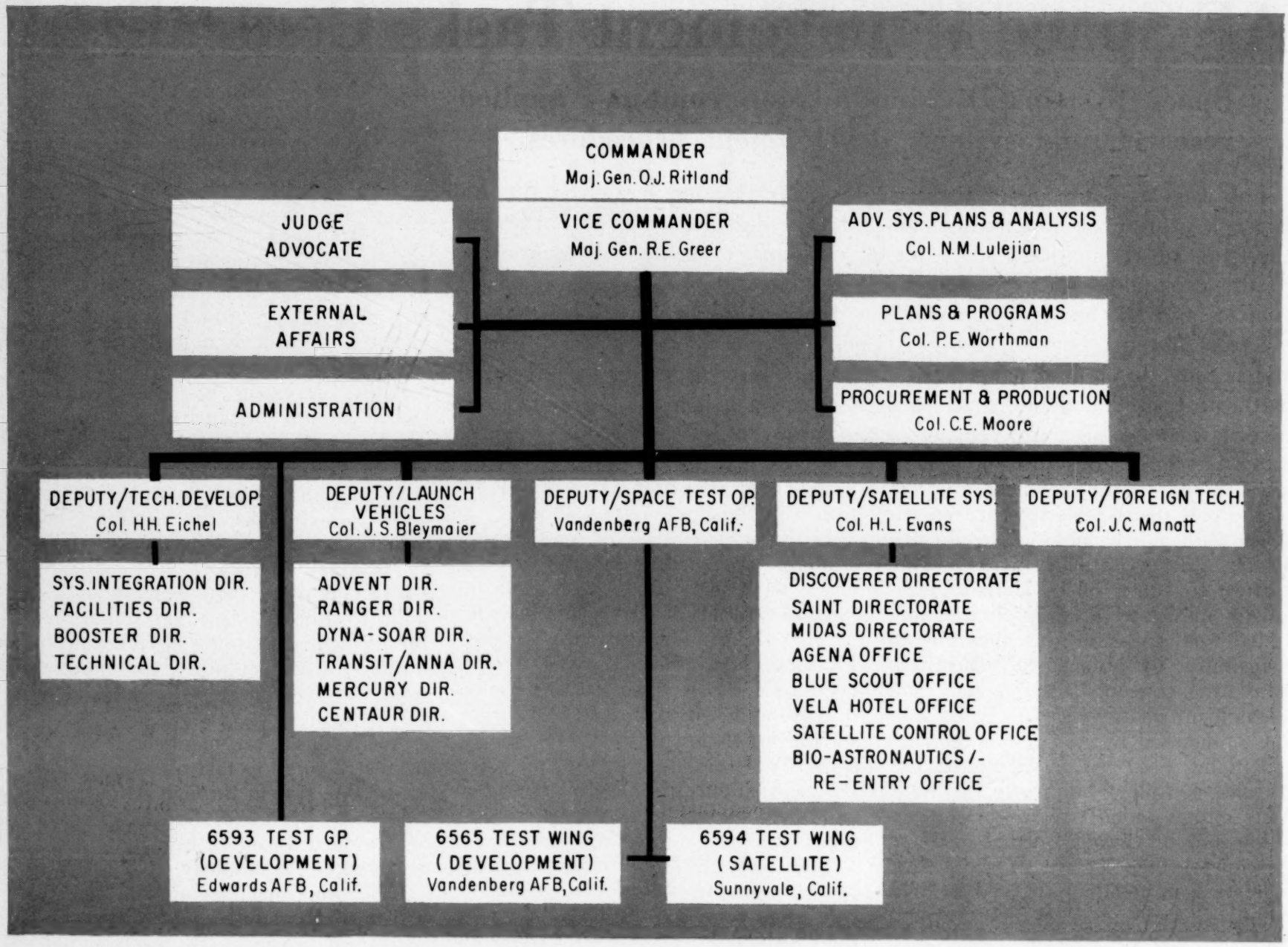
With this clear mandate, SSD has been structured to take a launch vehicle or satellite system through its entire development life cycle. Specific programs are assigned to one of four deputies:

- **Advanced technology,** Col. H. H. Eichel, who manages applied research and study programs designed to produce maximum advances in military space systems.
- **Launch vehicles,** Col. Joseph S. Bleymaier, responsible for procurement and launch of vehicle systems procured for Air Force, Army, Navy and NASA through SSD. Most of these are Thors, Atlases and Agenas.
- **Satellites,** Col. Harry L. Evans, who manages the designated USAF satellites, and satellites likely to mature quickly into the designated status.
- **Foreign technology,** Col. J. C. Manatt, monitoring Soviet scientific advances and achievements.

Systems Command labels those projects which have been funded for hardware as designated systems. In Space Systems Division, designated systems are Discoverer, Saint and Midas. A unique management technique, called "red line," is used for designated systems and for the Samos and Nova programs, which effectively eliminates the number of people who consider a project to those who can make decisions on it.

Red line means top priority, and the machinery to cut through layers of people means a decision takes no longer than three days, and is frequently made in a day. This is possible because a direct access line exists between the program director to Gen. Ritland to Gen.

Maj. Gen. Osmond J. Ritland, Commander of Space Systems Division, AFSC . . . born Berthoud, Colo., 1909 . . . received his pilot wings at Kelly Field, 1933 . . . assigned March Field . . . China-Burma-India theater as commander of Assam Air Depot, India, 1944 to 1946 . . . Second Command class, Ft. Leavenworth, Kan. . . . chief of Aircraft Laboratory, Wright Field . . . organized and commanded 4925th Test Group (Atomic) supporting U. S. nuclear weapons program, Kirtland AFB, 1950 . . . Industrial College, 1954 . . . Special Assistant to DCS/Development, USAF Hqs., 1956 . . . commander, 1961, AF Ballistic Missile Division . . . decorations include Distinguished Flying Cross, Bronze Star, Air Medal, Legion of Merit with Oak Leaf Cluster.



SPACE SYSTEMS DIVISION TABLE OF ORGANIZATION

Estes to Gen. Bernard A. Shriever, AFSC commander. Gen. Shriever is a member of the Designated Systems Management Group (DSMG) in the Pentagon, which is the final USAF authority in reprograming and refinancing projects, and was formed specifically to take advantage of technical breakthroughs.

With the red line, only those who make decisions are consulted, and rapid exploitation of a technical breakthrough is possible. Gen. Estes said a decision to reprogram or refinance a project to take advantage of a breakthrough is possible within three days.

Samos is in a different category, and is under the executive management of the Air Force Secretary. Maj. Gen. Robert E. Greer, SSD vice commander, is Samos manager within the command.

There are some SSD programs in late development but not yet in the systems category. They are Vela Hotel and Blue Scout, which may soon go into a program status from their current study category.

Executive management for these specific programs is vested in about 3,550 engineers, scientists and supporting personnel who make up the SSD staff. The headquarters element consists of 1,000 and the remainder are assigned to the Satellite Test Center in Sunnyvale; the Rocket Test Facility at Edwards AFB, and to launch squadrons at Vandenberg AFB.

The headquarters staff has been hampered somewhat because it has been forced to live in three scattered areas. Air Force has completed negotiations to purchase two office buildings from Douglas Aircraft Co. in El Segundo, and in about six months the entire SSD headquarters staff will move there.

Gen. Ritland and most of his staff are temporarily housed in the Aerospace Corp. building in El Segundo. A nucleus has moved to the Douglas plant, and the remainder are at the Aerospace Systems Arbor Vitae complex in Inglewood.

Program management and management skill of SSD inherently includes the capabilities of the Aerospace Corp., which is involved partially or entirely in each study or assigned project in the SSD inventory. Congressional and industry criticism of this arrangement has been defended many times with the philosophy that the SSD-Aerospace marriage gives a technical competence and objectivity to space programs that the Air Force could not otherwise obtain.

The criticism contributes to the driving force in SSD's early quest for performance results, and there are some in the Systems Command who hope that microscopic investigations will be a continuing influence in SSD's operations.

Fundamentally, Aerospace was created by the Air Force because there are not enough USAF personnel professionally trained and available to engineer and manage the spectrum of space programs. The existing "blue suit" capability is a hard and dedicated core, and many feel this core can ably manage any development program. The basic problem is numbers—too few experienced managers and far too many programs.

Air Force would like to develop a much larger in-house capability for technical management, but this is unlikely until government scientific and engineering jobs are made attractive economically. Gen. Estes feels career

officer training can be improved by reorganizing the Air Force Institute of Technology so that its capabilities are equal to the Navy's Postgraduate School at Monterey, Calif.

Lacking large numbers of engineering managers, the Air Force went through some difficult growing pains in management, and finally decided that a non-profit organization, without a competitive interest in projects, could help provide the link it needed between industry and the military. Aerospace is the result. Executive program management—the final decision—is the responsibility of Air Force officers, and Aerospace essentially has been given responsibility for systems engineering and technical monitoring.

Aerospace role in the organization of SSD goes somewhat deeper than specific project management. The corporation conducts a great deal of advanced planning, and evaluates new ideas which come in ever-increasing numbers from government and industry. In new programs, Aerospace evaluates technical proposals, defines work requirements and writes work statements.

Systems Engineering

Aerospace function in systems engineering has been defined as responsibility for establishing performance specifications, system objectives and target dates. Also involved in this responsibility are solution of compatibility problems, monitoring detailed design of subsystems and the prime system, monitoring progress and analyzing test data.

Air Force has defined Aerospace's technical role as one of general responsibility for component and system reliability and adequacy. In order to do this, the corporation has the power to resolve technical controversies, and to provide guidance to the over-all research and development effort.

Under this arrangement, the Air Force feels it effectively retains its responsibility for decision-making, and industry retains its historical proprietary and detailed engineering functions of fulfilling contracts. Aerospace supplements, and sometimes represents, Air Force as direct operating manager.

Specific programs in which SSD and Aerospace function as a team are:

- **Dyna-Soar booster:** the Dyna-Soar boost-glide vehicle is being developed under management of AFSC's Aeronautical Systems Division. SSD will develop, procure and launch the vehicles which boost the craft into ballistic and orbital flights.
- **Advent booster:** this synchronously-orbiting active communications program is managed by the Army. SSD will procure and launch Atlas Agena B vehicles for the first three Advent development flights, and Centaur vehicles for the operational satellite program.
- **Mercury booster:** SSD is responsible for procurement, modification and launch of 15 Atlas D launch vehicles for NASA's Mercury program, designed to launch and recover a manned satellite.
- **Bambi:** this is an Advanced Research Projects Agency (ARPA) study, assigned to SSD, to define an orbital interceptor-destruct system.
- **Saint:** this is a designated project in SSD to establish initial design criteria for a satellite inspection system. The division will carry the development to demonstration of satellite rendezvous.
- **Transit:** Navy's navigation satellite. Two-part SSD responsibility is procurement and launch of the Thor-Able-Star vehicle, and jointly working with the Navy to reduce payload weight to 100 lb. or less.
- **Vela Hotel:** a program being conducted jointly by SSD and the Atomic Energy Commission to develop a satellite system with instruments to detect nuclear detonations in space. SSD is partially responsible for the payload, and will procure and launch the Atlas Agena B carrier vehicle.

In varying degrees, Aerospace Corp. also performs a technical supervisory job for SSD in the Agena programs, but in somewhat less detail since Lockheed, the contractor, is specifically designated over-all systems engineer and technical director for this program. Aerospace generally supports the program by helping isolate technical ills, and solving them. Programs in this category are Discoverer, Samos E-1, E-2 and E-5 capsules, and the Midas early warning infrared satellite.

Management responsibility for SSD extends to three of AFSC's 28 technical areas, and procurement and launch of Atlas Agena B vehicles in NASA's Ranger project.

Technical areas are applied rocket propulsion, which involves the entire effort of the 750-man 6593rd Development Test Group at Edwards (see p. 103/Edwards); weapons fire control, and flight vehicle power.

Weapons fire control is another name for ballistic missile defense. SSD has no large hardware contracts in either technical area, but has a number of study contracts operating to define requirements in both fields.

Missile defense contracts cover such areas as flame spectra, background characteristics, sensors, kill mechanisms, scoring techniques, countermeasures and vulnerability. Non-propulsive space power, power conversion, transmission and utilization are being studied under SSD contracts in the vehicle power technical area.

The division is supported by both Aerospace Corp. and Space Technology Laboratories in its NASA Ranger program. STL has the contract for integrating the payload and vehicle launch, while Aerospace has made a series of trajectory studies and analyses.

The Ranger program recently was increased from five to nine payloads, with the probability that it will expand even more as a sort of pathfinder for the Apollo manned lunar landing mission. Two payloads—one launched last month—are called instrumented test packages, and the remainder, lunar impacters.

In addition to the 6593rd Development Test Group at Edwards, which is commanded by Col. H. W. Norton, Gen. Ritland's direct line responsibility

Aerospace Corp.

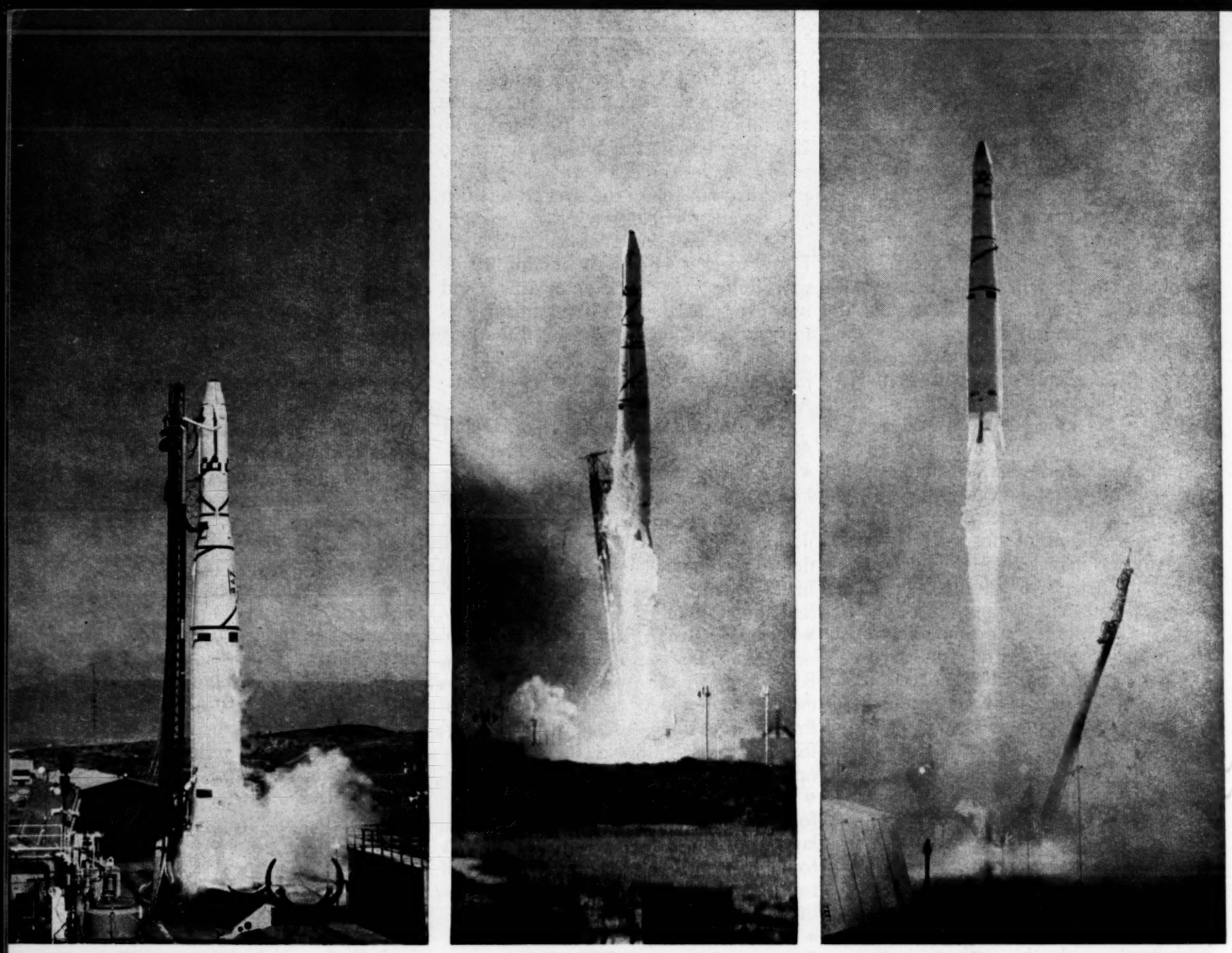
Los Angeles—Aerospace Corp., a non-profit organization formed more than a year ago, performs technical planning, direction and supervision of space programs for Air Force Systems Command's Space Systems Division, as well as for the ballistic missile programs for the Command's Ballistic Systems Division (AW, Aug 7, p. 52).

Space Systems Division programs which Aerospace Corp. is studying in its System Research and Planning Division include Project Phoenix and Step II Dyna-Soar, both of which are space launching systems, and satellite systems encompassing communications satellites, anti-satellite defense systems, orbital interceptor, reconnaissance and surveillance satellites and test support systems. Aerospace's Engineering Division programs, for which the company has various areas of responsibility, include Saint orbital rendezvous and inspection satellite, Midas and Vela Hotel warning satellites, and Samos E-5 and E-6 reconnaissance satellite systems.

Space Systems

Inventory of Air Force Systems Command operational space mission requirements centers around unrestricted development of these systems:

- **Workhorse booster or booster family, able to launch as many as 2,000 significantly heavy payloads over the next 15 years.**
- **Intelligence-gathering satellites, both manned and unmanned, for reconnaissance and inspection. This family of satellites could develop a strategic need for satellite weapons delivery.**
- **Unmanned communications and weather satellites.**
- **Manned laboratories and test stations to examine the cislunar and lunar surface environments.**
- **Lunar base to exploit any positive strategic potential of the moon.**



THOR BOOSTER LIFTS LOCKHEED AGENA OFF PAD AT VANDENBERG AFB

includes the 1,400-man force in the 6594th Satellites Test Wing at Sunnyvale, and the 400-man 6565th Development Test Wing at Vandenburg AFB.

The 6594th, commanded by Col. A. N. Moore, supervises tracking, command and on-orbit control, and recovery of satellites launched by USAF from the Pacific Missile Range.

Col. J. J. Cody, Jr.'s 6565th development wing at Vandenberg actually is a launch wing, and supervises the Discoverer, Midas and Samos launches on the Pacific Missile Range. This wing is developing a "blue-suit" launch capability for Atlas Agena B vehicles containing Midas and Samos payloads. Objective is to train a 200-man assembly, checkout and launch element consisting entirely of Air Force men. This element works with the contractors, who themselves have three to four launch crews active at all times at PMR. Target date for a ready launch crew is sometime next spring.

Although Samos and Midas possess the highest national priority, SSD and the Air Force recognize that the Nova solid propellant motor development assignment has given them a critical responsibility in demonstrating their management capability for the national space effort.

When President Kennedy directed that USAF and NASA would conduct parallel programs to develop the manned lunar landing launch vehicle, called Nova, he placed the two agencies in a recognized competition. It is unlikely now that either program will be scrapped when the Apollo vehicle is selected in two years because of the tremendous test and launch facility costs being earmarked for both solid and liquid propellant vehicles.

NASA Funding

Differences between the USAF and NASA developments require different test and launch facilities, which NASA will fund. The agency has selected Atlantic Missile Range as Nova launch site, and probably will build two pads for 12 million lb. thrust liquid fueled Novas and two for 20 million lb. thrust solid propellant Novas. The liquid Nova will have a booster cluster of eight F-1 engines, each of which develop 1.5 million lb. thrust. Solid Nova may be based on a cluster of 100-in. diameter motors.

At the present time, SSD's technical development deputy has responsibility only for motor development, and its progress in this program undoubtedly will dictate assignment of the booster stage. Program manager is Col. L. F. Ayers, who was transferred from Ballistic Systems Division to run the SSD project. Col. Ayers is building up the Nova management staff to about 20, and this group already has prepared specifications and the bid package, in anticipation of directing main line contracting and procurement.

Because Nova is designed to launch the NASA Apollo vehicle, both liquid and solid propellant configurations are to be built to NASA specifications. Among broad requirements are a 1,000 psf. maximum dynamic pressure, lift-off load of 8g and burning time of 85-100 sec.

Aerospace Corp. is in the unusual position of working for both Air Force and NASA in the solid propellant Nova program. Under a NASA contract, the corporation translated broad requirements into detailed design parameters. When the project goes to a contractor, SSD will be the Air Force agent for systems engineering and technical direction.

Military Space Technology Needs Are Urgent

Military capability for intelligence-gathering satellites has been technically demonstrated with the development payloads orbited in Samos and Midas programs, but an urgent need exists to extend military space technology in many areas.

Most critical research requirements exist in:

• Bioastronautics: Man must be mated to his machine as a useful part of a weapons system operating in an increasingly hostile environment. This requirement goes beyond life sciences and bioastronautics research, as it is conducted today, into an effort which extends from concept through the entire service life of a system. For military applications, research and operation must be performed by a single agency for effective solution of bioastronautics problems.

• Re-entry: Vigorous and extensive research in the entire re-entry field is required, with expansion of the Dyna-Soar program seen as an immediate need. The ballistic type of re-entry in Project Mercury has only limited usefulness in military space systems. Emphasis must be placed on coping with higher re-entry velocities and controlled landings from space flight. To obtain operational flexibility, basic new re-entry techniques must be developed.

• Satellite defense: This urgent requirement was made even more critical with the flight of the Soviet Union's Vostok II manned satellite. Capability to neutralize satellites from the ground is considered militarily inadequate, particularly since manned military satellites are certain to develop maneuverability and will be able to avoid ground-launched missiles. It is felt that the only sound approach to satellite defense is through use of other satellites—first unmanned, and then manned. Extensive research is needed now in orbital rendezvous techniques, and inspector sensing devices that can analyze payloads of other satellites. This includes requirements for attaching to other satellites so they can be inspected; de-arming techniques; repair facilities, and research on optimum methods of neutralizing hostile satellites and their possible armaments.

Much of the requirement for determining the strategic potential of space has become centered in the National Aeronautics and Space Administration's project Apollo.

With an equal technical voice given to Dept. of Defense and a little more money it is felt that Apollo can help make the strategic determination and meet civilian scientific objectives at the same time.

Without a military input, it may be necessary to duplicate both the program and the cost.

The over-all Apollo program will cost about $20 billion to place a three-man capsule into an elliptical earth orbit; on a circumlunar flight; and on a lunar landing and return mission. Crux of the difference between the NASA and SSD objectives in this program is that NASA will explore, and the military wants to seek means to defend.

The presently conceived Apollo program is expected to give the military valuable re-entry and space environmental data, but little else.

Without greatly extending or over-complicating the program, many missions which are essentially military in nature could be included.

Among them are the following:

• Rendezvous technique development, with maneuvering and docking. This is a requirement of the Saint satellite inspection system and of the Bambi satellite intercept system.

• Basic ICBM detection research, which in this case would be timing AMR and PMR missile launches to coincide with Apollo passes at 300-mi. altitudes. Observations may provide a telltale shockwave signature of enemy missiles. A possible long-range objective is to have a man in the observation satellite, who could respond quickly to the alarm and have the capability to destroy the missile.

• Van Allen radiation belt exploration, which would be a detailed and exhaustive sample so that the 25,000-mi. altitude of the belts will not be avoided because of fear that the environment is fatal. This phase of the program would result in developing shielding techniques and materials.

• High orbit environment exploration, at 30,000 mi., as the best potential altitude for an orbiting command post. Altitude is above the radiation belts and is virtually invulnerable to an enemy strike. Sizable satellite command post containing a military test space station is considered one of greatest manned space mission potentials when compared to the alternative of underground command posts.

The argument of multiple aims for Apollo is bolstered by other factors. High among them is experience. The military has been studying manned lunar installations since 1957, including mapping and determination of best landing sites. The Air Force points out that the first serious study of satellites, "Preliminary Design of an Experimental World Circling Space Ship," was completed May 12, 1946, under an Army Air Force contract with Rand Corp.

NASA puts into the $20-billion Apollo estimate all scientific and lunar programs which will contribute any knowledge to the cislunar and lunar environments. The total program includes projects such as Ranger and many satellites. Some industry planners maintain that the program is still over-estimated by a factor of two.

The only large capability for bioastronautics research exists in the Defense Department, and some fear that this capability will vegetate unless it is utilized in the national manned space flight effort.

There are 31 separate laboratories and centers in the military engaged in some form of bioastronautics research.

NASA makes wide use of seasoned military specialists in management of a number of its own programs, and the NASA administrator, James E. Webb, recently said they perform a vital task in the total national space program. Several hundred scientific and engineering graduates fulfill their military obligations annually while they are on detail to NASA.

Perhaps the strongest argument is that of capabilities. NASA cannot conduct the Apollo program without relying heavily on military men and military facilities, unless it duplicates this capability.

Air Force planners have outlined an ambitious program designed to make the findings on which hard requirements can be based.

Since Apollo has been made a national goal, they feel it is more logical to translate mission objectives to Apollo than to press for their own program.

The USAF program is based on a simple "can" sufficiently large to hold a 12-man crew. The crew would be ferried to the laboratory in a winged Saint II re-entry vehicle. Central module would be studded with docking and sealing interfaces so that a virtually unlimited number of additional modules could be added to the system.

USAF feels it must move with authority into manned space flight and booster development to attain a broad background in re-entry, configurations and design, structures and materials and guidance and control.

The serious concern is that the nation which first obtains the knowledge of the military implications of space will be the nation to exploit this knowledge.

USAF Developing Wide Space Capabilities

Space Systems Division is conducting a laboratory and flight program of direct experimental investigation to perfect the instruments and techniques on which the U. S. depends for military supremacy in space.

The laboratory for this sweeping responsibility is vast, extending from ground-bound test tubes through the solar system. Resources required to explore the potential for space systems are enormous in terms of money, minds and facilities. But the conviction is growing steadily that we can afford to pursue a vigorous military space program but we cannot afford not to.

It has become axiomatic that the non-aggressor in peacetime spends his time responding to the potential of the aggressor. If there is one striking characteristic of the military space program to date, it has been the requirement to obtain information about the Soviet Union—information which is freely available in the open society of the U. S.

Philosophy of the open society is to identify our strength, so that Russia will not make a fatal mistake by underestimating our capabilities and determination. Contrast this with the Soviet philosophy of secrecy and distrust. Only recently did Russia explain its space secrecy by saying it was too risky to disclose much, since a corrupt capitalistic society would use this information for purposes of aggression.

Satellite Warning

It is this Soviet philosophy which has established the nature of USAF space programs, because all are now in the category of intelligence-gathering satellites. The great proportion of research and experimentation under way in SSD is aimed at proving and improving the sensors and instruments which will tell us what the Soviet is doing strategically, and warn us of any impending Soviet aggressive actions.

The comprehensive SSD intelligence satellite development program is composed of Samos, Midas, Saint and Vela Hotel. It is supported by the workhorse Discoverer satellite series and by several hundred sounding rockets launched annually containing components and seeking critical data of the environment in which reconnaissance and inspection instruments will fly.

The requirement for intelligence satellites has been known for many years, but it became a vital national need when U-2 flights were canceled in May, 1960.

Although the question of space law is in its infancy, it is hardly likely that national sovereignty will extend any higher than the altitude that can be controlled, or defended. A satellite orbiting at an altitude of 300 mi. certainly is not invulnerable, but the U. S. has not objected to the Vostok manned satellites overflying the U. S. at 110 mi., and we are not apt to do so. Russia has made only meager, unofficial protests concerning U. S. reconnaissance satellites.

The Samos (satellite missile and observation system) satellite has been given the highest national priority because of its potential to provide the U. S. with a visual representation of what occurs in Russia in the way of missile launching sites, troop movements and other strategic operations.

Early development flights, four of which have been conducted to date, are designed to demonstrate the capability of making usable earth observations from space. The first five flights, using E-1, E-2 and E-5 capsules, will qualify instruments, electronics, the horizon sensor and ground support equipment.

Infrared Sensors

Midas, or missile defense alarm system, is a satellite containing infrared sensors designed to detect exhaust radiation from ballistic missiles. Since ICBM propellants burn only during the first few minutes of flight, a qualified Midas system of six or eight satellites for continuous coverage could increase warning time of an impending attack to 30 min., thereby doubling the time given by the ballistic missile early warning (BMEWS) radar network.

Like Samos, Midas has had four development flights with the objectives of qualifying the orientation system and obtaining base-line telemetry data on background infrared measurements.

Midas and Samos are closely akin in mission trajectories and in operation. Midas at 3,500 lb. is somewhat the lighter, but both are launched by Atlas Agena B vehicles; both have planned circular orbits of 300 mi., and they operate in a nose downward attitude; both payloads are actually a part of the Agena B stage which goes into orbit, and both can trace their genesis to the Discoverer program (see p. 99).

Data Link Telemetry

A major part of the Midas system is data link telemetry which will provide instant readout for early warning data. During the development program, readout stations are located at Vandenberg AFB and Kaena Point, Hawaii. Control and command point is at SSD's Satellite Test Center, Sunnyvale.

Agena B will play a major role in the next two intelligence satellites to be developed by SSD—Saint and Vela Hotel. Like Midas and Samos, these satellites will be an integral part of the Agena B stage, and will be launched by an Atlas D.

Philosophy behind Saint, which means satellite interceptor, is to inspect a foreign satellite before attempting to destroy it.

Saint I mission is considered a relatively elementary demonstration of a co-orbit to determine the characteristics and the intent of any foreign satellite.

Finned Titan Planned for Dyna-Soar

Finned Titan II vehicle will launch the 35 ft., 4 in. Step I Dyna-Soar suborbital vehicle to study re-entry velocities up to 22,000 fps., and a decision will soon be made on the launch vehicle to be used for the orbital Dyna-Soar glider.

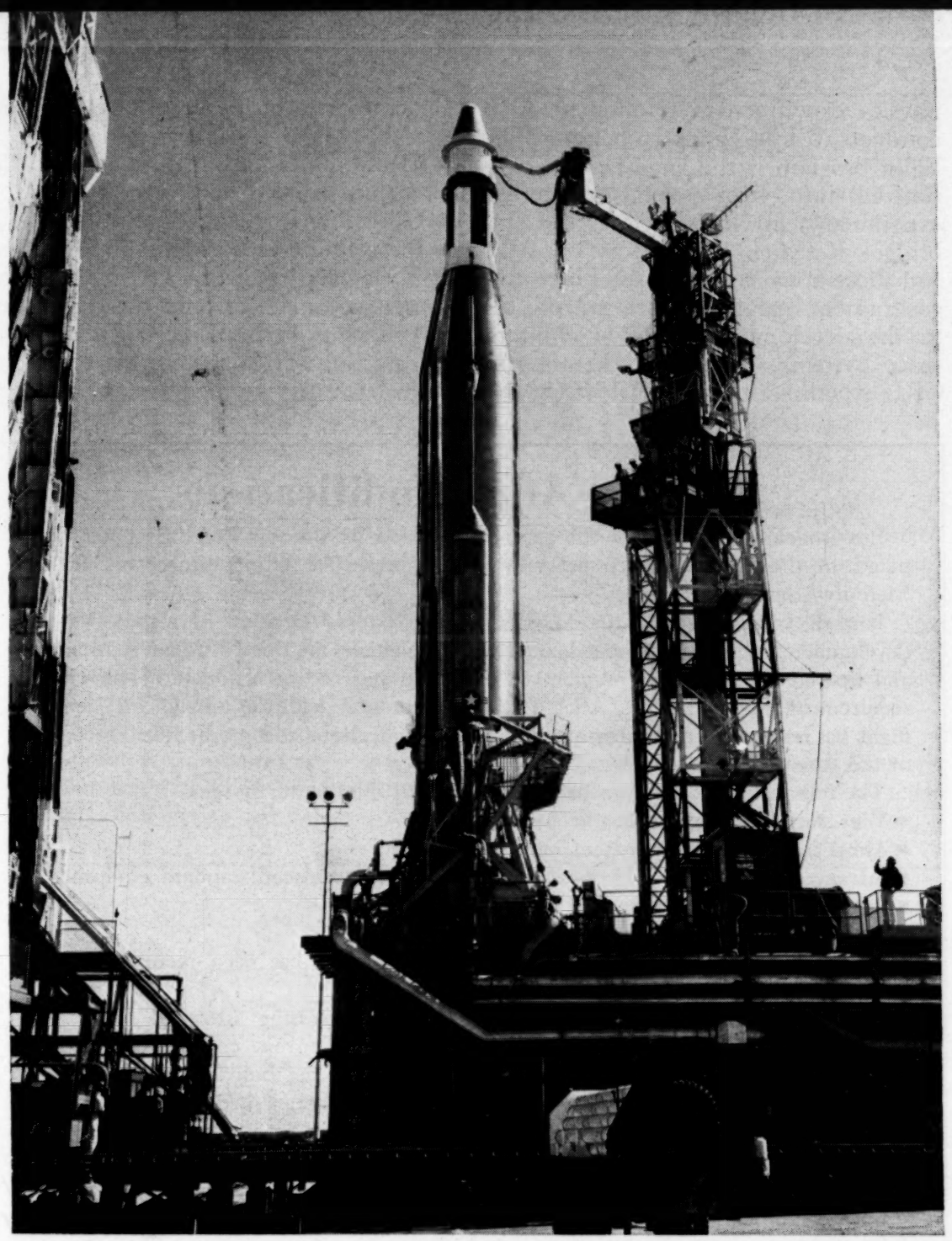
Three configurations appear to be in the lead on the basis of timing, economics and potential performance:

- **Standard Titan I with two 110-in. solid propellant assist-rockets strapped to the basic booster.**
- **Phoenix booster: A cluster of 100-in. diameter solid motors around a hydrogen-oxygen fueled engine such as the J-2.**
- **Saturn.**

The Step I Titan/Dyna-Soar configuration will be 129 ft., 8 in. long and will include a malfunction detection system (MDS), similar to the Project Mercury abort sensing system in the Atlas booster. Titan tanks will be strengthened and domes, barrels and struts beefed up to accommodate the manned glider.

Pad 20 at the Atlantic Missile Range is being modified to handle the Step I development tests. Changes are being made in the flame bucket and the concrete pad is being strengthened.

Vertical test facility is planned at Martin Co.'s Baltimore plant to test booster-vehicle dynamics and electronics compatibility.



ATLAS-AGENA B, now being used for a variety of military and civilian payloads, is checked out at Cape Canaveral prior to launch. This Agena carried a Midas payload.

An analysis has been made indicating that this unmanned vehicle can grow into a manned satellite system and become the ferry module for a multitude of manned space missiles.

The first flight demonstration cycle of the Saint program presently includes four test interceptions with payloads. Target satellites—probably inflatable spheres similar to the Echo passive communications satellite—will be launched into orbit by a four-stage Blue Scout launch vehicle.

The test vehicles, being built by Radio Corp. of America, will weigh 2,200 lb., about half the weight of the proposed operational Saint system. Program calls for launches to start within six months from the Atlantic Missile Range and flights are planned every three months. Rendezvous technique to be used will consist of Saint establishing initial contact with the target when the inspector is 50-mi. ahead and above the bogey. Retrorockets will slow Saint until it is within 50 ft. of the target. A homer will be used to complete the rendezvous and a television camera will establish the identity of the target.

SSD has awarded RCA a cost-plus-incentive contract for the Saint payload development job, and RCA is using this same contracting technique with its suppliers. One of the basic ground rules in the payload contract is to retain systems sensors in the current state of the art.

Vela Hotel

The fundamental aim in the Vela Hotel project is to develop new knowledge of the physical phenomena of nuclear detonations. Declaration by the Soviet Union, Aug. 30, that the atomic test moratorium no longer will be honored, and the initial Soviet test two days later, underscore the priority for this project, which in its operational phase would be a constant monitor of space nuclear tests.

SSD is assisting the Atomic Energy Commission in physical studies, and will develop the payload which will house AEC instruments.

Vela Hotel was transferred from a study to a program in late July and satellite design configuration was frozen Sept. 1. Instruments in this solar-powered package will be X-ray detectors, gamma ray detectors, a neutron detector, guard counters and electronic logics. In anticipation of program acceleration, two X-ray detectors flew piggyback on NASA's Ranger I satellite. Blue Scouts will carry X- and gamma-ray sensors in flights this fall. Full-scale satellites have been carried aloft to 120,000 ft. over New Mexico in balloon flights from Halloman AFB.

Operational Vela Hotel system would consist of six satellites, three orbiting perpendicular to the other three. Orbiting paths would be 50,000-75,000 mi., where background radiation is low.

During its study phase, Vela Hotel system was considered as a payload for both Thor and Blue Scout launch vehicles. Final decision has been to pack two identical Vela Hotel satellites into the same Atlas Agena B stage to correlate each other in detection. A solar storm, for instance, would not be recorded on both satellites, but a weapons test would. Vela Hotel is relatively small—the prototype package weighs 278 lb.

AEC's Vela program is in its research cycle in three distinct phases. Vela Hotel is the name for the space nuclear detection system; Vela Uniform is the project name for detecting underground explosions, and Vela Sierra is the name given for detection of surface detonations.

Although Blue Scout was eliminated as the Vela Hotel satellite launch vehicle, SSD has made extensive plans for this all-solid rocket in satellite and probe missions.

Origin of Blue Scout is in the USAF BRATS and HETS programs, which provided the genesis of NASA's Scout development and USAF's 609A test system. Cross fertilization has resulted in a reduced development cycle for both systems—Blue Scout became an operational launch test vehicle last month after its eighth test shot, and NASA's Scout ends its 12-vehicle development cycle early next year. Basic difference between the programs is that NASA has a single Scout vehicle, and USAF is developing six Blue Scout configurations. NASA's four-stage Scout uses spin stabilization for the fourth stage, and Blue Scout has a guidance package in its fourth stage.

Central configuration for both programs is an Aerojet Algol first stage, Thiokol Castor second stage, Hercules-Allegany Ballistics Laboratory X-254 third stage, and ABL X-248 fourth stage.

Air Force configurations evolved by mixing motors for two- three- and four-stage vehicles, with mission and payload

weight dictating configuration.

SSD has received delivery on five more Blue Scouts to be launched during the remainder of Fiscal 1962, the fifth designed to be the first satellite carrier. Three will be unguided probes, using three-stage Blue-Scout Junior configurations, and the fourth is a guided probe with a four-stager.

Paper requirements exist for a large number of additional Blue Scouts, and SSD wants to build a Scout launch complex at PMR to relieve some of the pressure from the AMR complex, which is the modified Vanguard tower. Among operational and experimental missions being discussed for the vehicle are:

- **Transoceanic communications,** possibly to give a jam-proof "go" order to strategic bombers on air alert. A 25-lb. package could be boosted to a 7,600-mi. apogee and link stations 8,500 mi. apart.
- **Carrier vehicle** for the Saint target payload.
- **Transit satellite carrier,** if a weight reduction program results in a 100-lb. or smaller payload. Navy wants to use an adaptation of Scout-Blue Scout for this navigation satellite mission, basing its vehicle on the first two stages of Polaris and the last two of Scout. Hardware development of Sea Scout, the Navy version, is unresolved.
- **Hyper-environmental testing** of drag brakes and re-entry models. Specific tests of Dyna-Soar models have been deleted from the Blue Scout mission because the combined costs of a 500-lb. model and the launch vehicle became excessive. Because of its capabilities, Blue Scout probably will be used for general configuration re-entry activity. The vehicle can carry a 500-lb. payload to 300,000 ft. at a 20,000 fps. velocity, and a 100-lb. model to 800 mi. with a 22,000 fps. re-entry speed.

Sounding Rockets

While SSD's satellite and vehicle development launches consume most of its resources and effort, it is generally recognized that sounding rocket experiments are the "bread and butter" of the laboratory. This is true because sounding rockets are cheap and effective in qualifying components for satellites and space probes. Rockets are reliable carriers for instruments for sampling the environment of phenomena through which space vehicles and spacecraft will fly.

There are two principal centers in the Systems Command's sounding rocket research program, and their work complements the activities of the entire command in space, missiles, aeronautics and electronics systems.

The Eglin Gulf Test Range and White Sands Missile Range are extensively used for component and physics experiments. (Holloman AFB conducts White Sands launches.) The Eglin program is the largest, and is organized into two general categories: experiments flown for USAF's Cambridge Research Laboratory (CRL), and those flown for other Air Force and government agencies. Both are critical to the development cycle of military space systems. Eglin will launch 66 CRL experiments in Fiscal 1962 in the general area of basic atmospheric research. Major flight categories are:

- **Electron and ion** measurements in the atmosphere.
- **Ultra low frequency** transmission.
- **Ionospheric measurements,** particularly density, resonance, structural components, and electronic characteristics.

Programs to be undertaken at Eglin during the next nine months consist of both basic and applied scientific experi-

Mercury-Atlas Modifications

Los Angeles—Indicative of the support provided by the Air Force Systems Command to the national space program is the exhaustive effort under way in the Mercury-Atlas (MA) system.

Launch vehicles deputy in AFSC's Space Systems Division is responsible for development, procurement and launch of MA vehicles in this National Aeronautics and Space Administration program to orbit and recover an astronaut. The critical requirement to qualify the Atlas D intercontinental ballistic missile for manned flight has resulted in a number of significant modifications and production procedures of the standard Atlas vehicles.

The following modifications have been made in the booster system:

- **Wet start configuration has been installed.**
- **Abort and stabilization systems have been added.**
- **Advanced autopilot and lightweight telemetry have replaced standard equipment.**
- **Retrorockets have been deleted from the airframe.**
- **Forward rate gyro pod has been added.**
- **Forward bulkhead has been thickened, and insulation has been increased in this section.**

The quality control program has been aimed at increasing astronaut safety, and has centered around an educational program for Convair contractor employes working on MA launch vehicles. This has resulted in the individual selection and marking of components and subsystems for Mercury flights. Procedure includes even engine clusters, since there is a spread of specific impulse among engines.

High specific impulse clusters were selected for early flights, but later boosters were selected as being standard.

One of the most difficult tasks in assuring pilot safety was the analysis of all Atlas flights to determine the optimum locations for abort sensors. These sensors will automatically actuate the escape rocket to pull the Mercury capsule away from the Atlas in the event of booster failure. It was determined that the mission should be aborted if these parameters are not normal:

- **Booster and sustainer fuel injection pressure.**
- **Sustainer hydraulic pressure.**
- **Bulkhead differential pressure.**
- **Liquid oxygen tank pressure.**
- **Missile-capsule electrical continuity.**
- **Control and backup rate gyros.**

Manual abort to back up the automatic system can be initiated by the test conductor, the NASA controller, the astronaut or the range safety officer.

The factory rollout inspection for MA-designated vehicles includes a pre-acceptance, acceptance and post-acceptance review and a final acceptance report, all of which are documented. An active flight safety review team has been formed on the pattern used for experimental and first flight aircraft. Members from industry and Air Force are experts in propulsion, airframe, guidance and electronics, electrical systems, flight control, pneumatics and hydraulics, propellant utilization and loading, abort and launching.

Because of two failures in the MA program, the quality control procedures have been unusually stringent. The exact reason for the failure of MA-1 (vehicle 50-D) has not been established but is believed to have been caused by a structural failure in the upper airframe.

MA-3 (vehicle 100-D) failed to respond to the pitch and roll program and was destroyed 41 sec. after launch. Several changes have been made in the programmer since that flight to eliminate stress and transient signal interference.

Space Systems Division hopes this experience in inspection and quality control will allow standardization of all systems and procedures on vehicles MA-5 through MA-15. Fifteen Atlas Ds have been ordered for the Mercury program, 10 of them designated for manned orbital flight.

Family of Boosters Defined

Space Systems Division has defined USAF requirements for a family of four launch vehicles and feels one additional workhorse vehicle and Nova will complete military booster requirements for the near future.

Maj. Gen. Osmond J. Ritland, SSD commander, sees a requirement for a vehicle equivalent to the C-47 aircraft, but considerably larger than anything now in planning. Lowest price and highest reliability could be obtained, he feels, by standardizing such a system and programing it for at least 2,000 launches.

The complete family would include Nova and these four systems:

- **Blue Scout, for light packages and for use in developing instrumentation and techniques for larger systems.**
- **Thor Agena B.**
- **Atlas Agena B.**
- **A two-stage configuration consisting of a solid cluster wrapped around a hydrogen/oxygen high energy liquid fueled engine. Designed payload capability would be 20,000 lb. into a 300-mi. orbit.**

Each succeeding vehicle in this family more than triples the capability of the vehicle it follows, and the inventory can run the mission gamut for light and heavy payloads launched into low, high or synchronous orbits and escape trajectories. Of the four "junior members," all but the last have been developed to the point where reliability is not considered a problem.

Booster requirement study was conducted by Aerospace and Technical Development deputate in SSD using as parameters operating economy of the systems, reliability, complexity and facilities required for test and launch.

ments. Among them are 30 Firefly project payloads, carried aloft by Nike-Cajun and Iris rockets. These payloads spew activated chemical elements to create artificial clouds, which are tracked optically to provide baseline measurements of air glow and wind activity.

Fiscal 1962 Firefly payloads will be high explosives, and clouds formed by salts, aluminum and cesium. Other 1962 experiments are:

- **Photo chemistry** in the upper atmosphere.
- **Magnetic field measurements,** and detection of electron and particle charges.
- **Techniques for precision** geodetic survey, which will contribute to the Project Anna geodetic satellite.
- **High altitude communications,** involving ionospheric techniques, transmission through the shock layer, radio-frequency voltage breakdown experiments and noise radiation measurements of the shock layer.
- **Radar cross-section** measurements.
- **Qualification of parachutes** for space missions, both in braking and recovery.
- **Measurement of extreme** ultraviolet.

Sounding Family

Systems Command's sounding rocket program is based on the use of off-the-shelf, standard research rockets. Those to be used this year are Arcas, the Astrobee family of 200, 500 and 1500-series vehicles, Nike Cajun, Aerobee 150 and 300, Percheron, a Nike-Nike-Cree configuration, and Exos. A Canadian Black Brant has been purchased for flight test later this year.

Both Eglin and Holloman will continue to launch large numbers of the Arcas-Robin high altitude wind research payload. This program actually constitutes the bulk of the Holloman sounding rocket effort. The Robin payload is a one-meter Mylar balloon carried to a 40-mi. altitude by the Arcas rocket. The balloon flight, tracked by radar, gives a reliable plot of wind activity and shear.

Holloman sees a pressing need to extend its launch capability to the Blue Scout Junior for Samos and Midas instrumentation improvement programs. Optical and infrared equipment can be flown over the White Sands Range to demonstrate effectiveness of instruments over land masses. Launch and recovery could be conducted within the range boundaries.

Radiation Studied

Air Force Special Weapons Center at Kirtland, N. M., which does not launch payloads from the center, is heavily involved in a two-year piggyback program using Atlas and Titan pods and a primary program using Blue Scout Junior. Objective is to develop instrumentation to measure the biological hazards of nuclear radiation. A secondary objective is to determine the composition of the turbulent "interface" area where the magnetic field of the earth meets that of the moon.

Fundamentally, Kirtland is responsible for determining nuclear and radiation effects on weapons. To do this, the center will instrument 14 Atlas and Titan pods and three Blue Scout Junior payloads over the next two years to accomplish the following:

- **Determine the effects** of re-entry on various reactor materials and working fuels. Several chemical agents will be added during re-entry to determine property change.
- **Study the properties** of reactor materials—beryllium and zirconium—when they are toxic.
- **Sample electron spectra** and measure albedo neutrons.
- **Measure biological effects** with tissue equivalent chambers in Scout payloads. Chambers are fabricated to duplicate the atomic makeup of a human being.

Pod payloads will take measurements up to an altitude of 620 mi., and Scouts to 125 mi. Experiments using ICBM pods will be made from both Atlantic and Pacific Missile Ranges and all Blue Scout Juniors will be launched from AMR.

These primary Space Systems Division programs, managed and funded by SSD constitute the major, but not complete, effort of the division. SSD is in a support role for all other space development projects in the military, and for several in NASA.

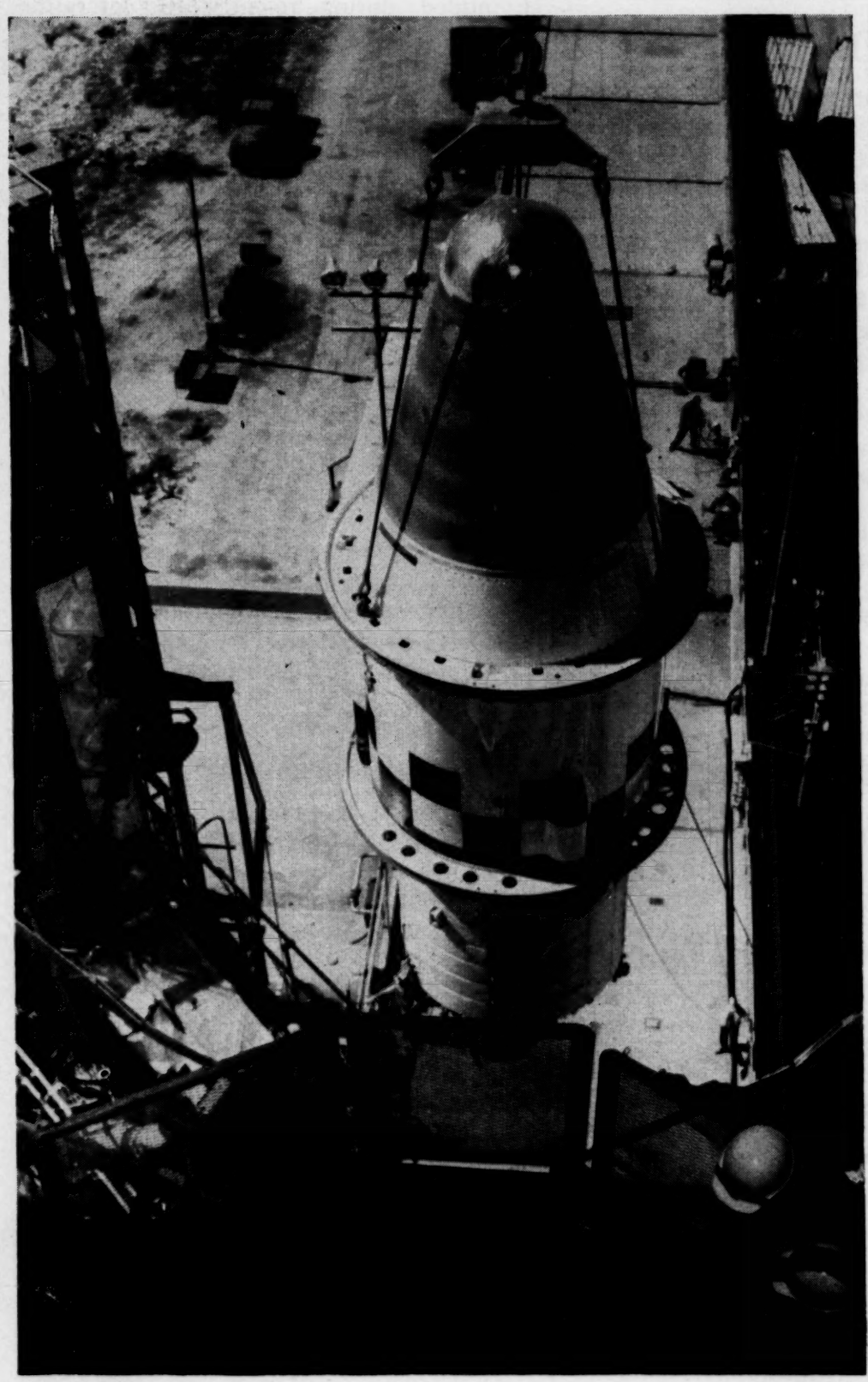
Booster Development

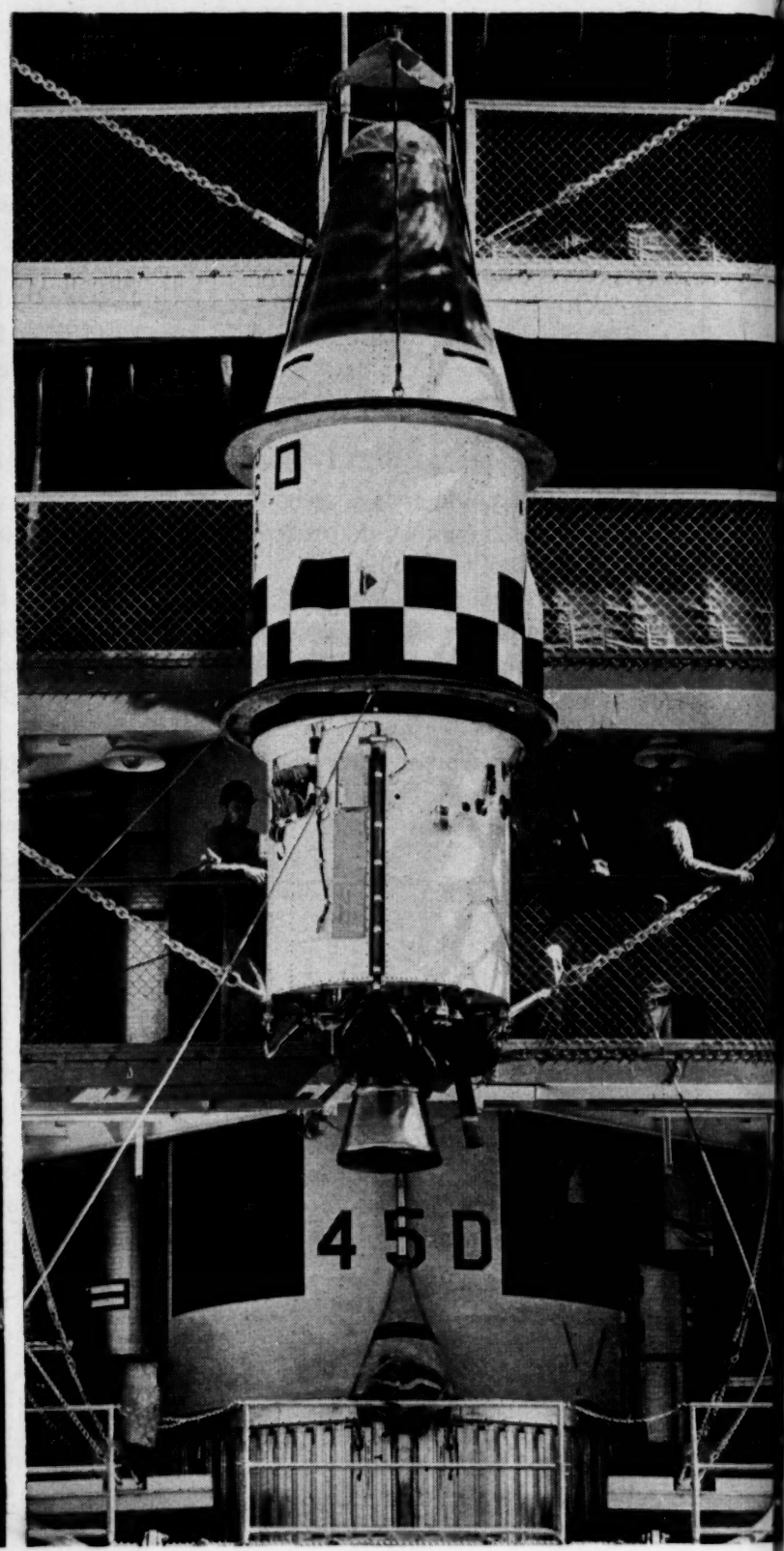
Support is provided in the critical areas of booster development and launch for Advent, Ranger, Mercury (see box, p. 96) and Transit programs for non-USAF agencies. Systems Command's Aeronautical Systems Division is responsible for the Dyna-Soar boost-glide vehicle, and SSD is supporting this project (see box, p. 94) in the same way as the others, by developing, buying and launching the booster.

SSD supports the Army in differing degrees in Anna and Advent programs, and the Navy in Transit. The basic difference in Army programs is one of degree. Army Advent Management Agency manages the payload portion and data reduction for this communications satellite. In Anna, SSD is responsible for giving the Army raw geodetic data provided by a USAF satellite.

Important elements of these programs:

- **Advent:** A project to demonstrate the 24-hr. orbiting active communications repeater. It will be launched by Centaur into an equatorial, circular orbit of 19,300 naut. mi. Program will start with three demonstration flights using Atlas-Agena B, which can provide orbits with periods of 4-5 hr. SSD will provide the specially tailored Agena stages for Phase I, the Centaur for Phase II, launch, on-orbit control, tracking and telemetry readout services. The Army-developed payload is being built under systems management of General Electric.
- **Anna:** A joint geodetic satellite program relinquished by NASA to the Defense Department last fall. The Army will manage the program, and essentially, SSD will conduct development to





LOCKHEED-BUILT AGENA upper stage, carrying a Midas payload in its nose, is raised to the top of the gantry to be mated with its Atlas booster. Earlier Midas flight tests used the "A" model of Agena; subsequent flights are using the larger version Agena B.

Army requirements. This means essentially that SSD will manage payload instrumentation development, launch the booster, track and recover the payload and deliver data to the Army. Army will process and reduce the data and furnish results to the other services.

Problems Arise

A series of problems have arisen in the Advent program which are certain to delay the launch schedule. Most critical has been the difficulty in developing the liquid hydrogen engine which will power the second stage of the Atlas-boosted Centaur launch vehicle. Development ills, many minor, have piled one on the other so that first test flight will be at least eight months later than the original schedule of last July.

The second problem area is considered less serious. Centaur will be limited to 1,250 lb. in payload weight with the Advent mission—synchronous equatorial orbit. The payload now weighs about 1,400 lb., and a major effort is under way to reduce structural and insulation weights.

The Navy's navigation satellite, Transit, was designed primarily to provide precise position data for nuclear submarines for computing Polaris missile trajectories. In the SSD organization, Transit and Anna have been placed in the same directorate because both will use the Thor AbleStar launch vehicle and consequently have the same launch, tracking, data collection and control problems.

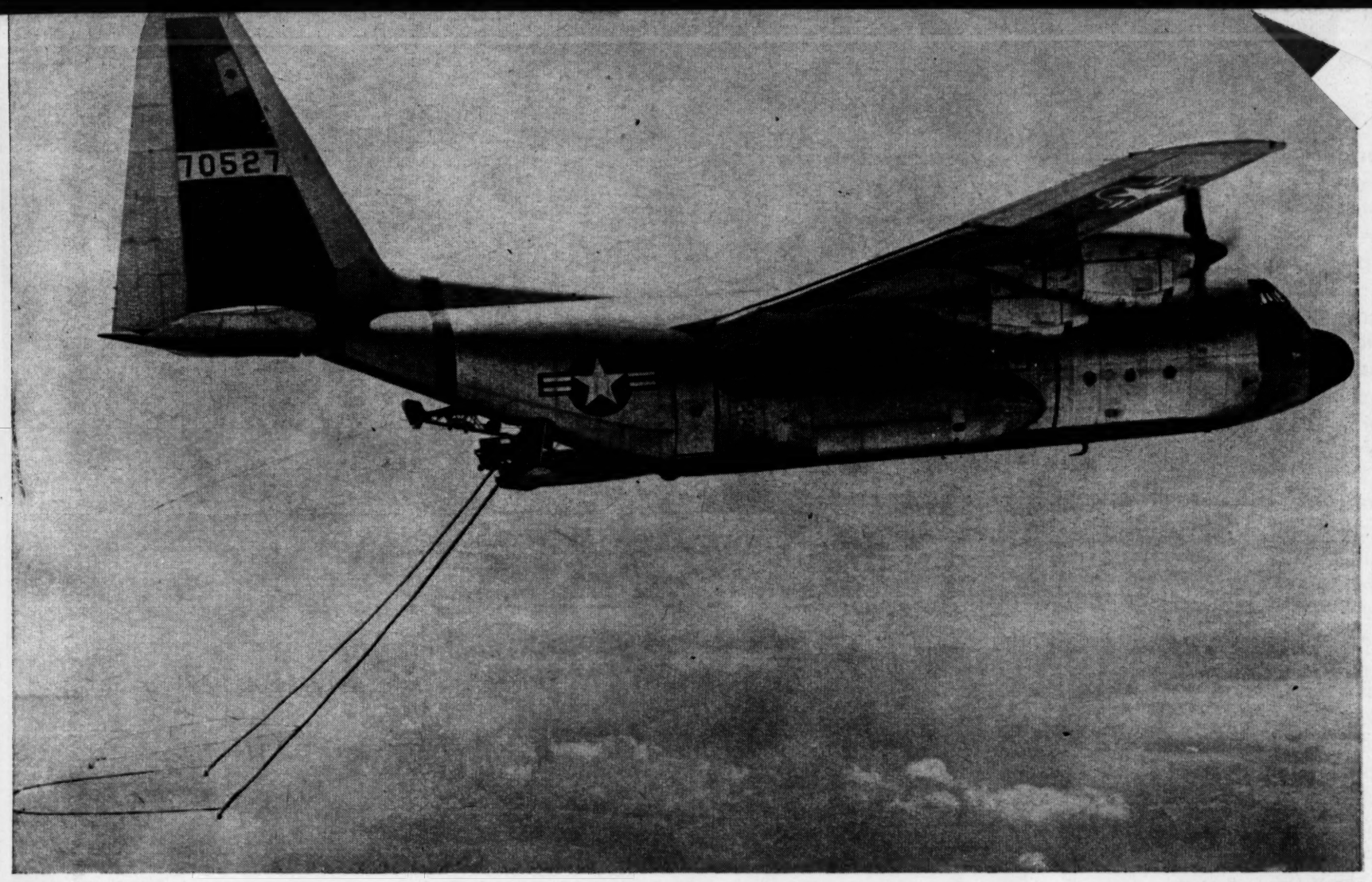
NASA's Ranger, launched by Atlas Agena B, differs markedly from Samos and Midas despite use of the same vehicle. Ranger separates from the Agena stage, and Samos and Midas remain a part of the stage.

Major effort in SSD is to design a standard Agena B to accommodate all NASA payloads which will use this stage.

NASA Purchase

In addition to Ranger, NASA will buy Atlas Agena Bs for its eccentric orbiting geophysical observatories (EGO), and solar observatories (OSO).

The most attractive consideration so far involves building a constant airframe, 10 ft. in diameter, which will eliminate the complicated interface between launch vehicle and payload.



USAF JC-130B Lockheed Hercules, with Fulton Skyhook and All-American Engineering mid-air retrieval system, will replace the C-119 in the Discoverer aerial retrieval program. The 6594th Recovery Control Group, Hickam AFB, Hawaii is responsible for capsule recovery.

Discoverer Becomes Satellite Test Bed

Sunnyvale, Calif.—Air Force Discoverer program, which was created to perform applied research to support development of military satellites, has expanded into a flexible satellite test bed with the capability to qualify advanced systems and components over the full spectrum of space technology.

Discoverer has reduced the development period for many satellite systems because its reliable vehicle and proven techniques have succeeded in compressing the experimental and developmental cycles into a single engineering flight test phase. Conspicuous success of the program (see chart, p. 102) has given it a vastly increased assignment. Space Systems Division, which manages the Discoverer series, considers it an open-end project which will be continued indefinitely.

Discoverer has made significant contributions to the Samos optical and Midas infrared reconnaissance satellites both in orbital tests of sensors, and in developing the Agena spaceframe which houses the satellites. Procedures devised in Discoverer which have carried over to Samos and Midas are:

- **Precise orbital injection.**
- **Attitude control in orbit.**
- **Command and on-orbit control** functions.
- **Ejection from orbit,** re-entry and recovery.

Precision Techniques

Space Systems Division will use the same precision techniques in the Saint satellite inspector system, and in Vela Hotel, a satellite designed to detect nuclear detonations in space.

The reliable procedures and hardware are not confined to USAF programs; a number of National Aeronautics and Space Administration projects will directly benefit from the Discoverer flights, particularly in reliability of the Agena B second stage. NASA has firm plans to use Agena B, launched by Thor and Atlas boosters, for 20 payloads and undoubtedly will increase this order for the Apollo manned lunar landing program.

As many as a dozen flights will be made with research and prototype models of the Apollo spacecraft to verify final design criteria. Other NASA programs to use Agena B are:

- **Ranger,** both mission qualification and hard lunar landing flights.
- **Rebound and rigid Echo** passive communications satellites.
- **Nimbus third-generation** meteorological satellite.
- **Geophysical observatories,** both for eccentric and for polar orbiting trajectories.
- **Topside sounder,** a joint National Aeronautics and Space Administration-Canadian payload which will measure the ionosphere from above.

Heart of the Discoverer program from a development standpoint is the Lockheed Agena B second stage, which has an integral Bell Aerosystems' high energy propulsion system. The Bell engine is fueled by unsymmetrical dimethylhydrazine (UDMH), with red fuming nitric acid used as oxidizer. This propellant combination has a specific impulse potential of 250 sec., and the Bell engine produces 15,000 lb. of thrust with its re-start capability.

Agena Development

Agena has successfully sidestepped any serious development problems in its Discoverer application, probably because its origin stems from the Convair B-58 program. Known as the Bell Hustler, the engine was designed to power the B-58 weapons pod. Although never used for this purpose, the Bell Hustler established the fundamental engineering design for the Agena propulsion unit.

First version used in Discoverer was Agena A, which had half the tankage of the B model, and only one burning

AGENA SPACE VEHICLES are shown under construction at the Lockheed Missile and Space Co. plant, Sunnyvale, Calif. Note fuel tanks for the Bell rocket engine, nose cones that house Midas, Samos and other specialized space payloads and main fuselage sections.

PRODUCTION-LINE techniques are employed for final modification and checkout of Agena satellite vehicles at Lockheed Missiles and Space Co.'s facility at Vandenberg AFB. Checks are made on the satellite's propulsion, control, guidance, attitude and other systems.

cycle. The re-start capability and longer burning time originated with Agena B, flown for the first time on Discoverer XVI Oct. 26, 1960. Thrust level of the Douglas Thor was increased by 15,000 lb. to 165,000 lb. with the flight of Discoverer XVIII on Dec. 7, 1960.

Agena's space reliability can be traced largely to the exhaustive testing program conducted on the propulsion system and stage by Air Force Systems Command's Arnold Engineering Development Center in Tullahoma, Tenn. Tests of the bell engine were made on the ignition system, thrust, total impulse, and the re-start capability under conditions simulating high altitude in full-duration firings.

A major contribution by Arnold was the design of an optimum nozzle extension for the Bell engine. An extension with a large expansion ratio is necessary for efficient operation at altitude, but each engine type differs in its requirement for the best nozzle size. Arnold conducted tests of varying expansion ratios with a variety of graphite and metal alloys.

Much of the Discoverer investigations at Arnold consisted of measuring performance characteristics so that baseline data could be developed for computing precise trajectories. Among systems tested were:

- **Ullage rockets,** two 1,000-lb. solid propellant motors used to accelerate the Agena while it is coasting at zero gravity in order to seat propellants in tanks and fuel lines. These engines were fired to determine if exhaust at high altitude would damage adjacent Bell engine nozzles.
- **Spin rockets on the Agena** stage were fired to determine reliability and flame impingement on the state structure.
- **Retrorocket performance.** A 1,200-lb. thrust motor is used to decelerate the Agena vehicle for re-entry. After several attempts to recover Discoverer capsules failed, the retrorocket was referred to Arnold, where altitude firings indicated the aft closure burned through, seriously reducing the effectiveness of the system. These failures were caused by exhaust gas impingement on the nozzle, a phenomenon which did not effect sea level performance. The system was fixed by strengthening the nozzle at the impingement point.
- **Base plate operation** was tested to assure that it would separate cleanly from the re-entry capsule, and not be forced back into the capsule from turbulence or the low pressure field in the wake. The base plate shields the recovery from re-entry heating.
- **Parachutes,** tested to determine opening shock. This project resulted in use of a ribbon pilot 'chute system, and a strengthened main 'chute.

With the propulsion unit essentially standardized, both Space Systems Division and Lockheed would like to have a standard Agena stage because at the present time, each mission calls for a different stage configuration.

The Discoverer Agena, for example, is 19 ft. long. Midas uses a 25-ft. stage, and although NASA's Agena has the same dimensions as the Midas stage, the internal configuration differs greatly. The Midas payload includes the entire Agena structure, while NASA payloads will be separated from the stage.

One of the problems in the Agena program is its wide use. Production could keep up with requirements if the assembly line could produce a stage which is 80% complete, instead of the present procedure of fitting each vehicle to a mission. Presently, a "standard" Agena on which various payloads can be bolted to meet different mission requirements, on the many projects using the Agena vehicle, is being developed.

Like the program it supports, Discoverer is in itself a complete space system and Agena is but one part in many. The complete launch vehicle system is the Thor booster, and Agena B second stage. Thor originally was developed as an intermediate range ballistic missile and is on station with the Royal Air Force in the United Kingdom. In its space role, Thor had boosted 34 of the nation's 48 successful satellites into orbit as of Sept. 1.

The complete Discoverer system includes not only the launch vehicle, but extensive ground facilities, and the capability for air snatch and sea recovery.

Discoverer ground complex is managed by Space Systems Division's 6594th Satellite Test Wing, located at the Satellite Test Center in Sunnyvale, Calif. Commanded by Col. A. N. Moore, the wing includes tracking elements in Kaena Point, Hawaii; Kodiak, Alaska; New Boston, N. H. and Vandenburg AFB.

The Satellite Test Center (STC) is oriented for real-time analysis of flight data with a communications network that includes 100 and 60 words-per-minute message and data transmission teletypes, voice circuits, single sideband radios and high frequency radios.

The satellite control room has direct responsibility for satellite command and control functions for all Discoverer shots immediately after a successful launch from Vandenberg. The room is manned by a mixture of test wing and Lockheed personnel, with the objective to have a full USAF staff conducting missions by the time the Midas and Samos systems become operational.

Data from tracking stations is processed through computers and displayed on a closed circuit television system directly on control room consoles. Static screens are supplemented by dynamic screens which display traces of the vehicle trajectory and orbit.

The 6594th Test Wing, which is expected to provide the nucleus for operational space systems, was activated with

launch of Discoverer IX on Nov. 20, 1959. The first eight Discoverers were controlled from the Lockheed Scientific Research Laboratory in Palo Alto, Calif. An interim control room was used for Discoverers IX through XIX, and the permanent control room went into operation Feb. 17, 1961, with the launch of Discoverer XX.

STC Manpower

Although manpower from STC will go to operational units, Col. Moore says the center itself will remain in a research and development status. An operational center would not require the sophistication of Sunnyvale, which is equipped to handle Discoverer, Samos and Midas, and is responsible for parts of these other systems:

- **Transit:** the Navy's navigation satellite. STC assists in tracking and computing.
- **Advent** the Army's active communications satellite. STC will assist in tracking, telemetry and control for the first four development flights.
- **Vela Hotel and Saint:** precise role of STC in these systems has not been defined, but probably will be similar to Midas and Samos since they are SSD development systems.

Normal launch procedure takes 22 days, five for missile assembly, 14 on the pad and three days to rehabilitate the pad for the next launch.

The 6594th Recovery Control Group, with headquarters at Hickam AFB, Hawaii, is an element of the 6594th Test Wing and is responsible for capsule recovery. Space Systems Division is not satisfied with the Discoverer recovery record (see box) and a systems improvement program is continuing in recovery techniques and procedures.

Discoverer Designs

Some Discoverer packages are designed to eject recovery capsules; others perform their required functions while remaining on orbit with no requirement for recovery. Seven capsules have been recovered to date, four in air snatches and three from the water. Recovery problems lie not so much in that the aircraft miss the capsules but stem from a requirement to precisely control the re-entry path. If the capsule comes down within range, the recovery group normally can snatch it. The group is replacing its C-119 recovery aircraft with JC-130s which have better range and electronics systems.

The early problems in recovery were hazy for a long period because little was known about temperatures in space.

The fact that one side of the satellite was exposed to the sun and the other to the earth greatly affected electronic components. SSD determined that a positive method should work, and painted the outside of the capsule. This approach did not succeed, and finally another technique was used —heaters were installed on batteries and gas jet systems.

Early Problems

There were early problems in stability, which greatly affected the recovery path. Solution was to replace solid reaction motors with compressed gas jets.

One series of failures was believed to be caused by parachutes, and this resulted in the program at Arnold which brought about new designs and deployment techniques.

The future of the Discoverer program is fairly well established, but there are several areas already isolated for refinement and improvement. In addition to re-entry and recovery, which are considered of primary concern, the "product improvement" program includes added performance for the Agena vehicle, a capability of the Agena to carry out rendezvous missions, and a capability of Agena to carry electric and nuclear propulsion systems on orbital tests.

Now in its third year, Discoverer has a record of achievements in launch, orbit and re-entry technology. In launch technology, the system has resulted in a reliable carrier vehicle, design requirements for support equipment, precise booster ignition and cutoff, precise orbital injection, and proper orientation during the burning and coast phases. These operations laid the groundwork for launching on a regular schedule, which will average about 18 Discoverers a year.

Orbit Technology

In orbit technology, Discoverer has achieved and maintained precise polar orbits, with an accurate horizon stabilization system. The Agena B has restarted after a near-complete orbit. The instrument package has carried power units to respond to ground commands, and the payload has measured space environments and evaluated abvanced components.

Re-entry achievements include design of a capsule and components to gather and transmit data, and a system to re-orient the Agena and separate the re-entry body.

Discoverer Launch History

Success	Failure
1959	
I—Feb. 28	III—June 13
II—April 13	IV—June 25
V—Aug. 13	
VI—Aug. 19	
VII—Nov. 7	
VIII—Nov. 20	
1960	
XI—April 15	IX—Feb. 4
XIII—Aug. 10*	X—Feb. 19
XIV—Aug. 18*	XII—June 29
XV—Sept. 13	XVI—Oct. 26
XVII—Nov. 12*	
XVIII—Dec. 7*	
XIX—Dec. 20	
1961	
XX—Feb. 17	XXII—March 30
XXI—Feb. 18	XXIV—June 8
XXII—Apr. 8	XXVII—July 21
XXV—June 16*	XXVIII—Aug. 3
XXVI—July 7*	
XXIX—Aug. 25*	

Total—29 launched, 19 successful, as of Sept. 1, 1961
* Successful recovery

Agena B Engine

The Agena B engine, which has an uncooled nozzle extension and a re-start capability, is the fourth Bell engine used in the Discoverer second stage. The latest version, designated 8096 by Bell Aerosystems, was preceded by:

- **Engine 8001, similar to the Bell Hustler and fueled by JP-4 with inhibited red fuming nitric acid as oxizer.**
- **Engine 8048, the system used in most Agena A stages. Unsymmetrical dimethylhydrazine replaced JP-4 as the fuel.**
- **Engine 8181, which provided the first re-start capability for the Agena.**

MIDAS mated on Atlas Agena B.

LEUHMAN RIDGE rocket test stand facilities have been used for missile and space vehicle engine testing ranging from the original Atlas configuration to the 1.5-million-lb. thrust North American F-1 engine.

Propulsion Dominates Edwards' Effort

Edwards AFB, Calif.—Applied propulsion research management is emerging as the dominant activity here, with a nearly ideal environment available for the evaluation and ground test of liquid, solid and nuclear fuel systems in the critical launch vehicle development cycle.

Several hundred simultaneous test programs are being either managed or conducted here, with about 95% of the $50-million annual effort going directly to industry in contracts. The in-house research effort is aimed primarily at stimulating industry research in advanced concepts.

The propulsion research program is conducted by the 6593rd Test Group (Development), which was formed here two years ago by a manpower nucleus from the Power Plant Laboratory at Wright-Patterson AFB. Established primarily to provide general direction in propulsion research for missiles and military space systems, the group has expanded its capability to include across-the-board research in propellant chemistry, components, engines, stages and ground support equipment.

This capability comes with an experienced contractor base, which in Fiscal 1961 consisted of 60 firms and 145 separate contracts. Another philosophy is to require each program manager to defend his progress quarterly at a 45-minute technical review.

Col. Harold Robbins, deputy commander, said the command element holds technical reviews on a nearly continuous basis. Detailed resources reviews are held each week.

The quarterly technical review assures that each program manager has visited the contractors' plants at least once since his last report, and Col. Robbins feels that the questioning by management is such that solid program analyses are made.

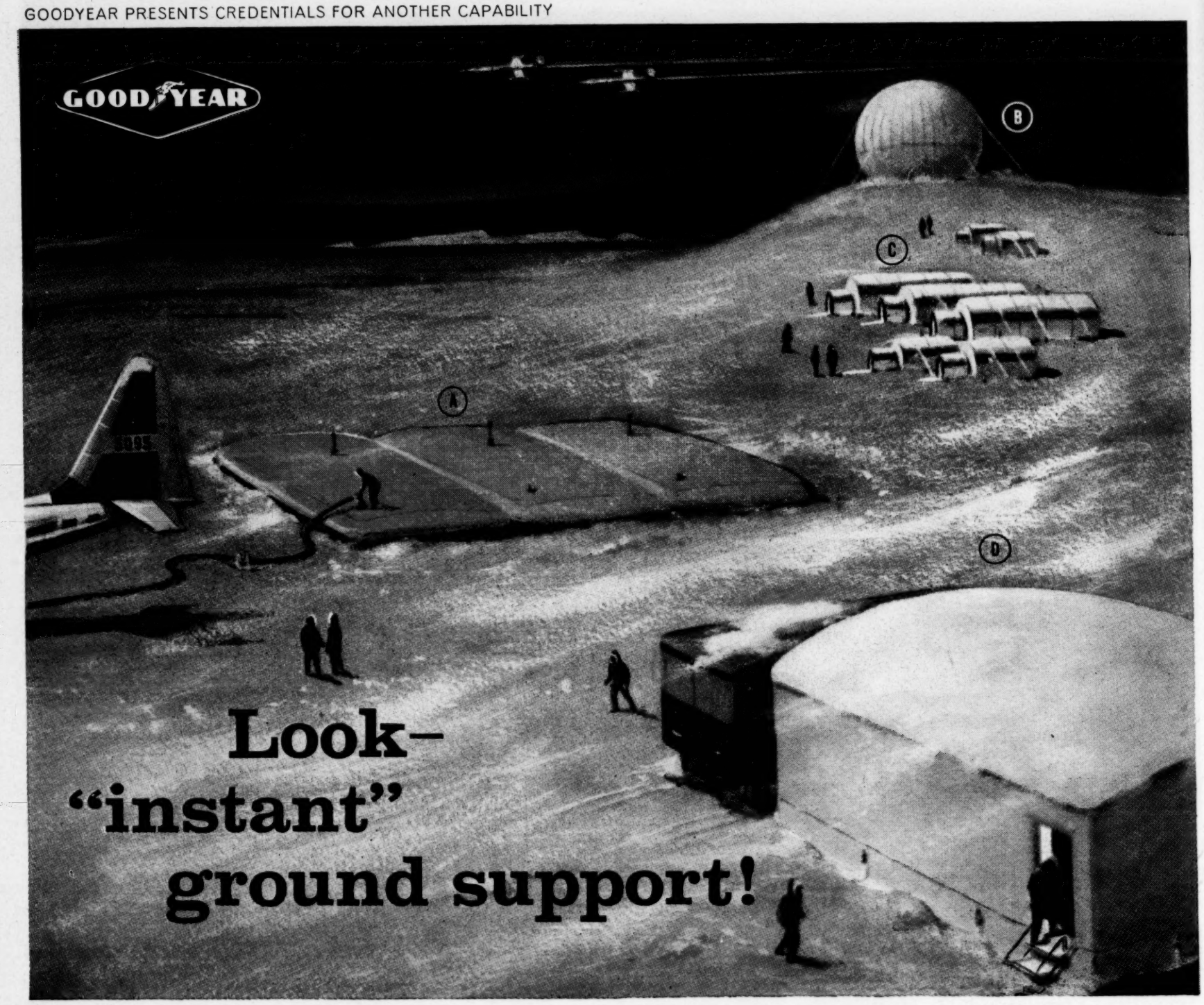
Test positions, laboratories and shops of the group are located in the remote Leuhman Ridge areas of the Edwards complex, providing natural mountainous protection for experiments involving hazardous and toxic propellants. Existing facilities are available both to government and industry for performance evaluations, feasibility demonstrations, environmental tests, component compatibility, safety, toxicity and hazard tests, reliability determination, propellant characterization and combustion experiments.

Some of the larger engine development and evaluation programs conducted in these cells include Titan propulsion reliability, a comprehensive valve evaluation program, test of Minuteman and Scout motors and development of the GAM 87A (Skybolt) and GAM 83 (Bullpup) motors. Evaluation of the new Titan upper stage Chariot engine will be conducted here.

Major test support functions are performed for NASA at three F-1 test stands, the Centaur test stand, and engine and attitude control propulsion cells for the X-15.

Although the major activity of the test group is managing industrial contracts and conducting its own research, it has been given responsibility for these additional projects:

- **Engine development** and evaluation.
- **Test support.**
- **Solid fuel** ingredient analysis for the



Here's a brand of inflation that's easy to take—Goodyear's inflatable structures that can take to the air in folded form, blossom out on-site into tough, lightweight shelters, radomes, fuel farms.

Shown above are a few recent developments in rubberized fabrics by Goodyear:

(A) **Fuel Farm** of PILLOW Tanks—these huge containers can be set up, filled and pumping in minutes. Drained, they roll up like rugs for compact storage and transport. Capacities to 50,000 gallons or more.

(B) **"Soft-Top" Radomes** by Goodyear provide all-weather protection that shrugs off snow, ice, 150-mph gales. In sizes to 100 feet in diameter, Goodyear radomes offer highest transparency to radar waves. Even radar antenna is inflatable in new design above.

(C) **Personnel Shelters** of Air Mat fold into light packs, inflate in minutes. Provide comfort and protection in worst weather. Ability to hold air eliminates air-locks and need for constantly running compressor.

(D) **Mobile Command Post** features Goodyear's 9-inch Air Mat fabric—with highest strength/weight ratio known. Stored in truck side, structure unfolds and inflates to room 25-feet-square in 15 minutes.

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Advanced Research Projects Agency (ARPA).

- **Mutual weapons** projects for rocketry.
- **Coordination activity,** formal and informal, as the principal Air Force propulsion representative on inter-agency panels.
- **Specifications and standards** for rockets, propellants and subsystems for Air Force and, in some cases, the Defense Department.
- **Represent USAF** in Joint Study Requirements on Propulsion.
- **Long range planning** in rocket technology and propulsion test facilities requirements.

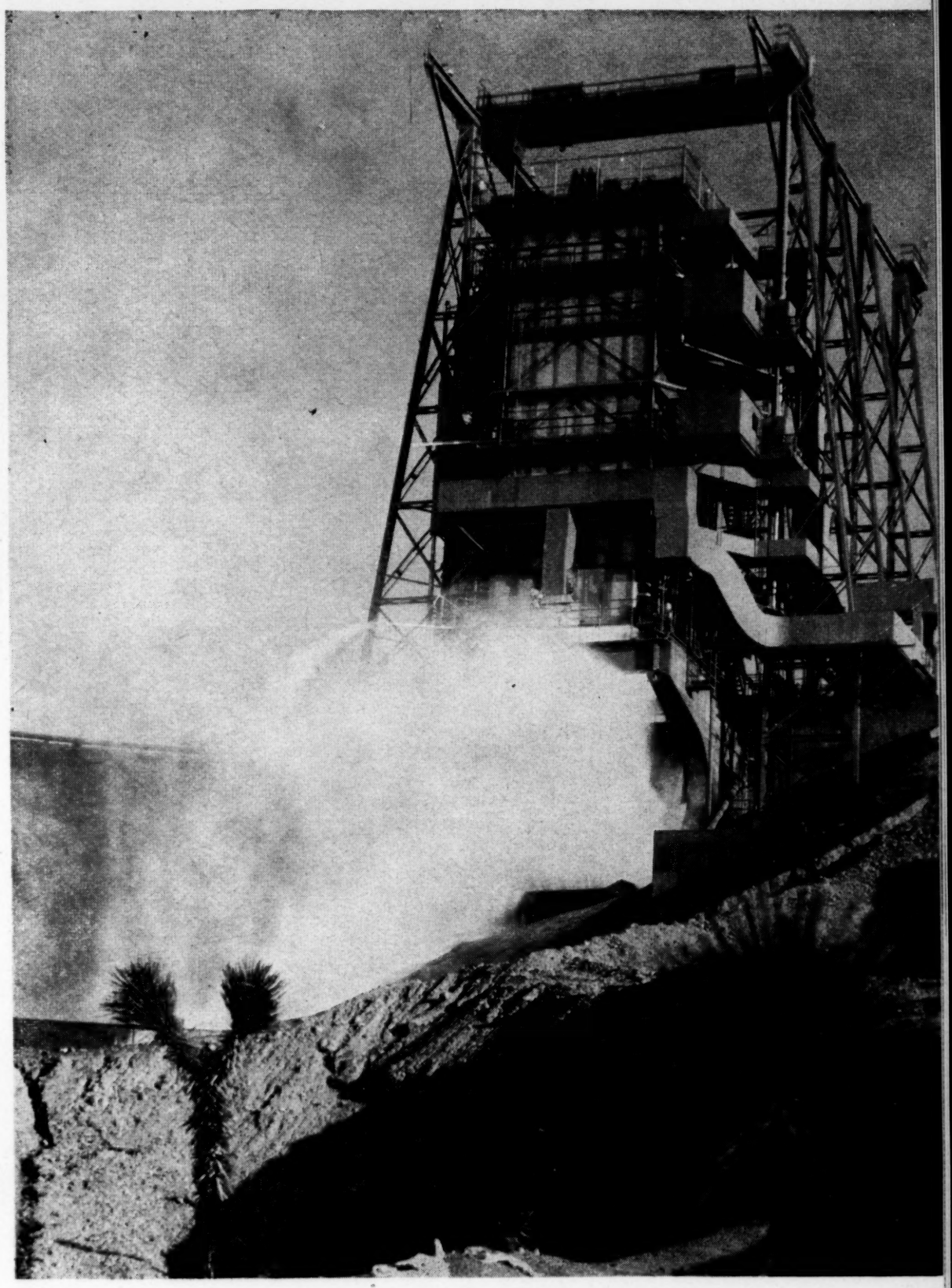
The propulsion team has developed an optimum propulsion research and development cycle which carries a concept to an integrated system in three years.

Typical first step would involve simultaneous two-year studies in concepts and feasibility of such components as nozzles, injectors, chambers, pumps, tanks, pressure systems, propellant utilization, high energy propellants, application and design studies, throttled combustion, impulse controls, valves, regulators and fittings, zero g restart and feed, and thrust vector control.

After these exhaustive experiments would come performance demonstrations of the principal components—thrust chamber, pump, tankage and feed and controls—which would be made during the third year.

Within the specific areas of documented projects, the test group has primary responsibility for applied research in liquid and solid rocket technology, the propellant chemistry of liquids and solids, propulsion subsystems, applications studies for nuclear rockets, development of rocket test equipment, development of sled rockets, ground environmental test support equipment, rocket scaling studies and the nuclear rocket powerplant.

In component development and engineering, the group is responsible for propulsion systems for the Bomarc, GAR-9 (Falcon), MB-1 (Genie) and Mace/Matador.



FIRING of 1.5 million lb. thrust rocket engine on Edwards AFB test stand.

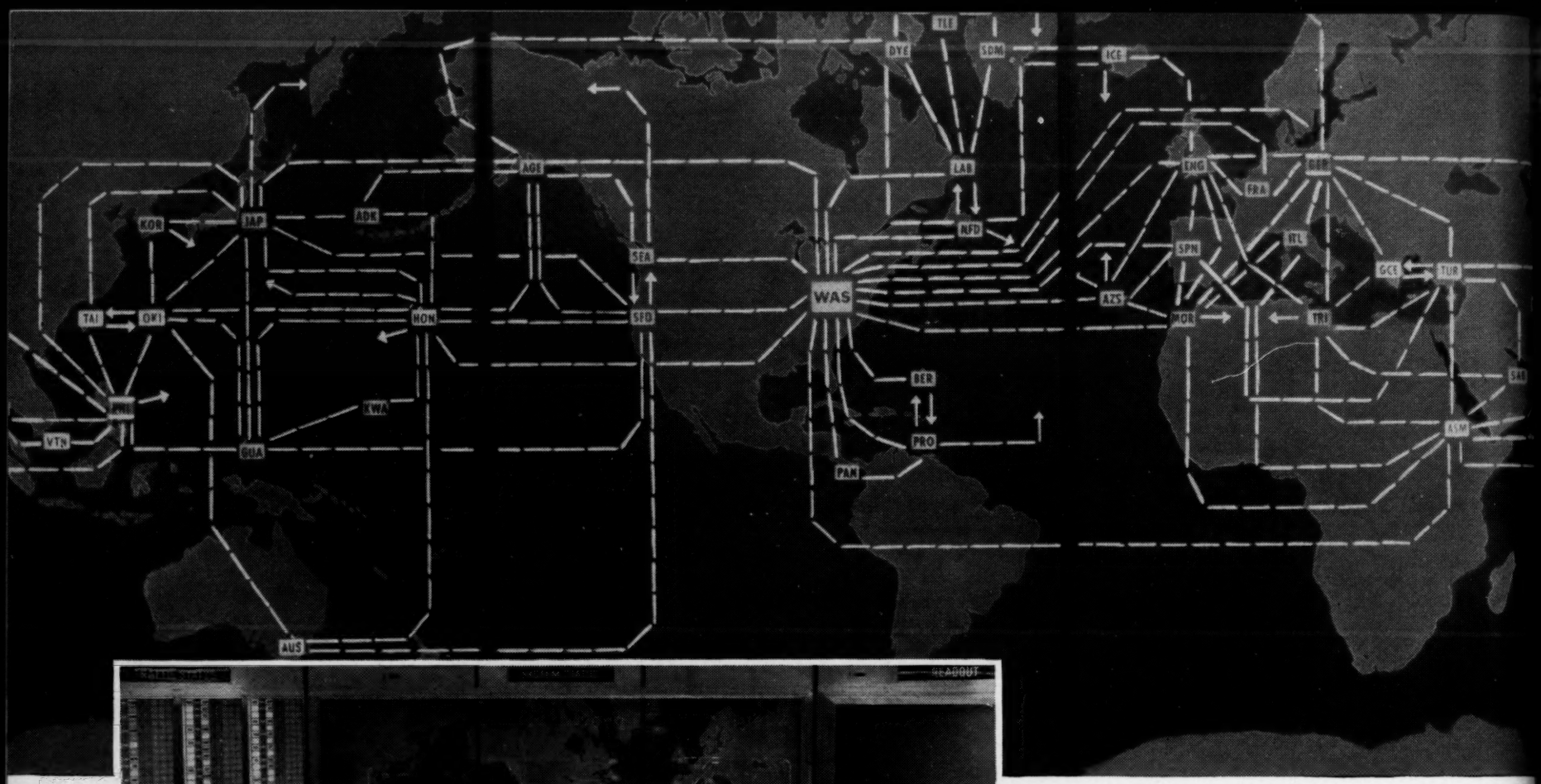
Research Areas

Currently, the group is emphasizing these research areas in its propellant technology programs;

- **Liquids:** advanced nozzle studies, pressure chamber concepts, injectors, and pressure-feed and pump-feed systems. In propellant applications, studies are under way on gels, additives and monopropellants. Throttles and impulse controls are being studied as means of maneuvering liquid propelled vehicles.
- **Solids:** advanced materials, hardware, fabrication and design techniques; advanced propellant systems and formulations; advanced engine concepts in segmentation, grain design and thrust vector control. The Edwards group monitors the Navy's work in hybrid systems.
- **Electric propulsion:** studies in ion, plasma and thermal arc systems; feasibility of orbit changing and logistical support; engine control and installation features, optimizing propellant fuel systems.
- **Rocket propellants:** new formulations in high energy compounds for both liquids and solids; storability, availability and low cost for liquids and additives, aging and mechanical effects for solids.
- **Nuclear technology:** control systems, shielding, lightweight and high-performance impulse engines.

Within this broad base of technical responsibilities, the test group is stressing in its contracts a comprehensive program of chemistry and components. A representative inventory of existing contracts shows the depth of activities:

- **Tripropellant performance.**
- **Large segmented** booster feasibility.
- **Advanced nozzle concepts,** such as reverse flow, plug, uncooled and thrust vector control.
- **Analysis of multi-million lb. thrust** boosters, including the economics of a variety of liquid and solid systems.
- **Low-cost injectors.**
- **High mass-fraction solids.**
- **Fluorine oxidizers.**
- **High and low pressure** combustion chambers.
- **Grain design computers.**
- **High-energy monopropellants.**
- **High mass-fraction** cryogenic tankage.
- **Hydrogen mass** flow meter.



The Defense National Communications Control Center by Philco

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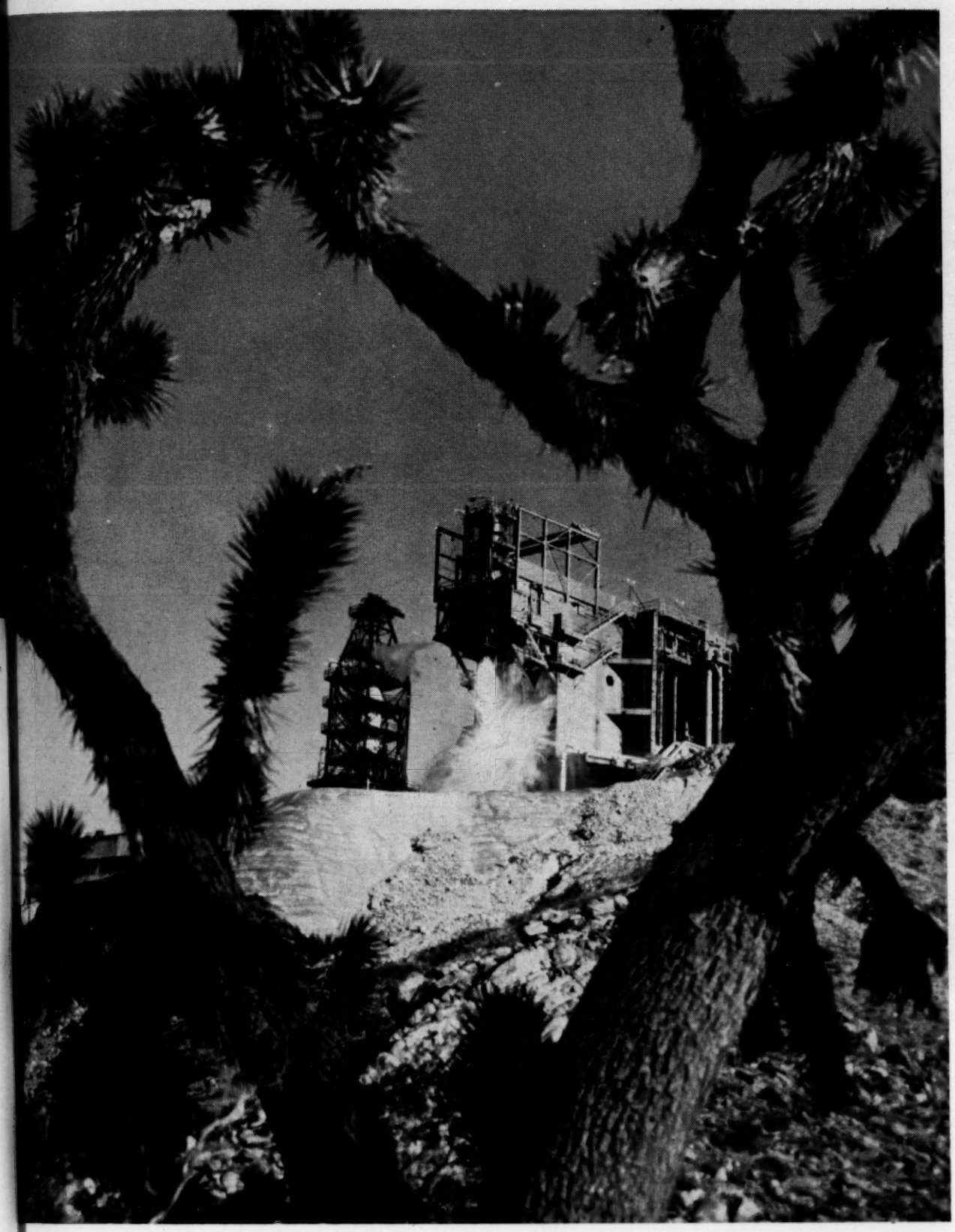

PROPELLANT SYSTEMS test stand and rocket engine test stand firing at Edwards AFB.

- **Sodium azide** pressurization systems.
- **High-energy** polymeric binders.

The propulsion research group, which consists of 223 engineers and scientists in its total work force of 863, is undertaking these in-house projects:

- **Storable propellant research,** principally with a combination of pentaborane and hydrazine.
- **Gelling, or thixotropic experiments,** using silica gel and carbon black additives.
- **Low-pressure space rocket feasibility,** involving cryogenic fuels. Tests at 5 psi. already have been run in this system, which is described as extremely simple.
- **Headless solid motor test and design,** in which the nozzle of the stage above acts as the closure for the stage below, reducing the need for large interstage structures. The nozzle in this concept is filled with propellant. In tests so far, propellants weighing up to 2,000 lb. have been ignited successfully.
- **High energy monopropellant** combustion, with effort centered around new chemical compounds with a high specific impulse.
- **Cellular combustion chamber** concept, in which all engines in a launch vehicle would exhaust into a common nozzle.

Gas Bleed Method

The group is investigating the chamber gas bleed method of solid fuel rocket thrust vector control, ignition and re-start of solid propellant motors, and combustion stability.

The test position complex includes

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SR. DESIGN ENGINEER—Supervision of a group in design of solid rocket motor components. Requires professional degree and a minimum of 5 years rocket design experience.

ENGINEERING ANALYST—Systems Design. To formulate mathematical models of systems engineering problems and implement solutions by analytical techniques. Requires degree with solid mathematical foundation and 2 years design or systems experience.

PROCESS ENGINEER—For rocket motor processing studies and process methods improvements. Requires chemical engineering degree and direct propellant processing experience.

PROPULSION ENGINEER—For analytical studies of solid and liquid propulsion systems. Requires degree with extensive mathematics, thermodynamics and fluid mechanics background.

All qualified applicants considered without regard to race, creed, color or national origin.

For complete information contact C. F. Gieseler, Dept. 106

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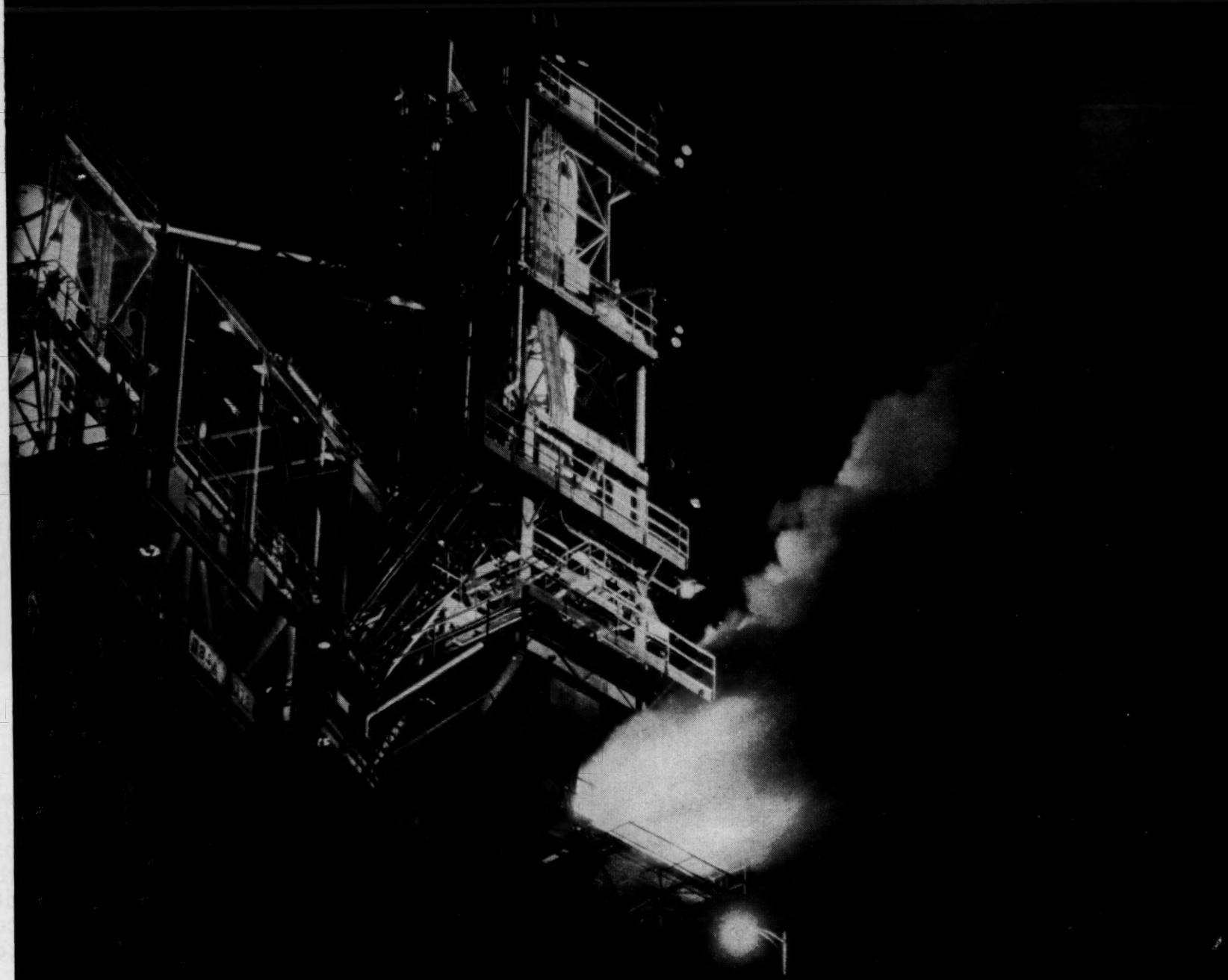

NIGHT FIRING on rocket test stand at Leuhman Ridge facility at Edwards AFB.

46 engine and chamber cells, hazard and toxicity test areas and a family of silo launchers with associated pressurization and tank flow loops. Eight cells are used in liquid fuel applied research, with thrust ratings of 100,000 lb. to 700,000 lb. Three NASA stands are used for testing the F-1, 1.5 million lb. thrust engine. Thirty-two cells are available for component and subsystem testing in liquid, solid, electric and nuclear systems and propellants.

There are four 40,000 lb. thrust stands for testing very toxic propellants, and two 1.5 million lb. thrust solid booster test stands.

Hazardous and toxic propellants are also investigated in the isolated Haystack Butte section, where large spill tests are made with cryogenic and hazardous propellants.

The propulsion group has management responsibility for Advanced Research Projects Agency (ARPA) contracts involving advanced solid propellant ingredients. These include syntheses of beryllium hydride, aluminum fuels, and of high energy oxidizers; an integrated ingredient program; compounding hydrazine polymers and encapsulation research.

The Edwards team is the focal point for mutual weapons agreements with Italy, France and Germany calling for data exchange and technical support.

The test group is responsible for both Air Force and military specifications for rocket engines, propellants and subsystems and for establishing standards for inspection procedures of a number of chemicals and compounds.

The group has been active in the propulsion aspects of 18 Air Force study requirements, including Saint, launch systems, intelligence reconnaissance, three earth satellite weapons, five lunar systems, positive control bombardment, a small ICBM, aerospace plane, nuclear propulsion system, space logistics, recoverable booster and the military test space station.

The objective is to forecast the technology which will exist in propulsion—

6593rd Test Group's Responsibilities

Edwards AFB, Calif.—Mission of the 6593rd Test Group (Development) is to:

- **Conduct applied research in liquid, solid and hybrid chemical rocket propulsion; military application for nuclear rocket propulsion and associated ground support equipment.**
- **Provide engineering consultation to the Defense Department, National Aeronautics and Space Administration, Atomic Energy Commission, Advanced Research Projects Agency and industry in propulsion and test facility requirements.**
- **Conduct advance planning and studies in propulsion.**
- **Establish specifications and standards for procurement of propellants and propellant compounds.**
- **Test components and systems for reliability.**
- **Support contractor development tests.**

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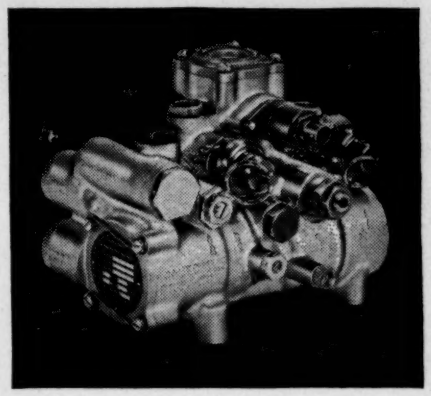
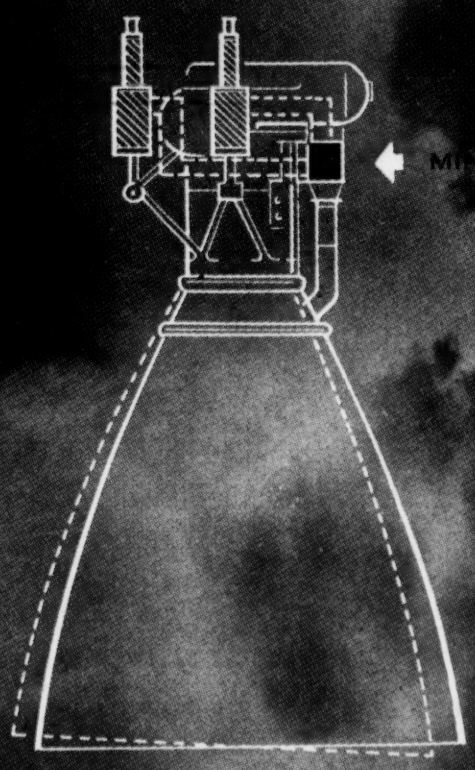


HYDRAULIC POWER PACKAGE

This miniaturized unit provides a positive power source for 360° directional control of satellite rocket...yet a dozen precision assemblies fit into package weighing only 8¼ pounds and less than 8 inches long...gear type motor delivers 2.4 hp at 8.7 gpm and 840 psi with UDMH fluid...piston pump flow ranges to 1 gpm at pressures to 4000 psi, speeds greater than 11,000 rpm.

Each component assembly can be used individually or in the power package produced by Lear-Romec for your hydraulic application...write to Lear-Romec for details.



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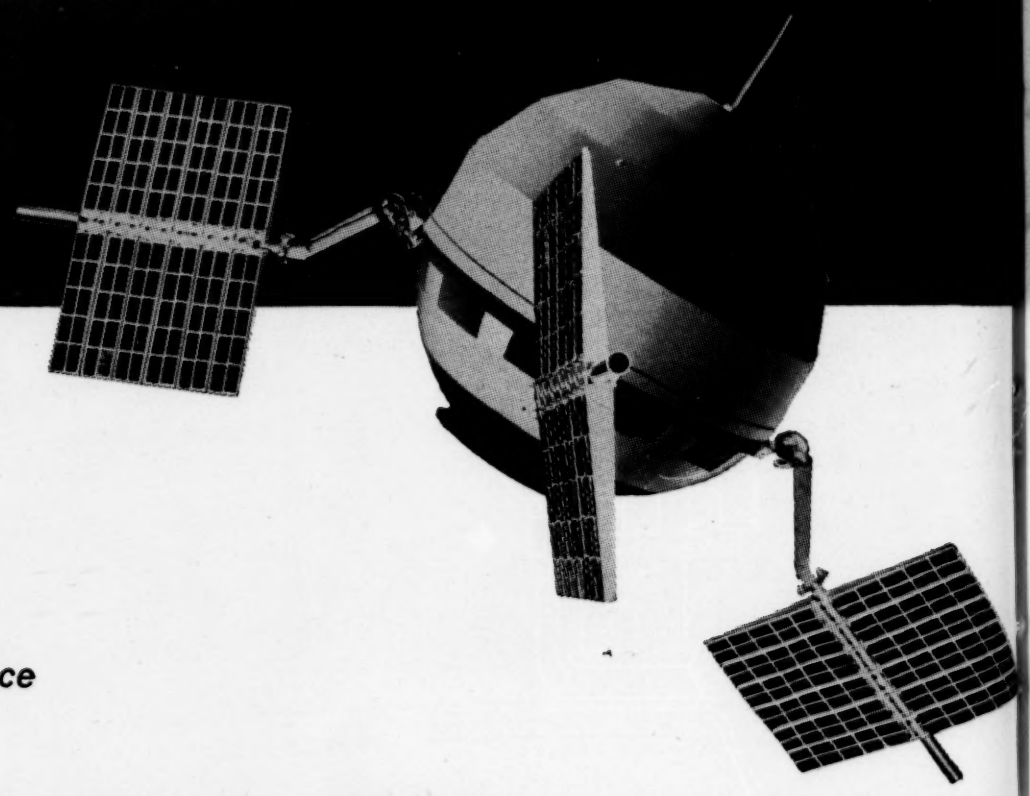
BETWEEN THE CELL AND THE SUN



The Role of Vacuum Deposited Coatings in Space

Probing the depths of space, America's satellites seek out and transmit back to Earth vital information needed in the desperate race for the moon and mastery of the planets. Because weight is a deadly enemy of the space vehicle, featherlight silicon solar cells are used to recharge batteries in such satellites as MIDAS, TIROS and ADVENT, and convert solar radiation to electricity that provides operating power for recording, transmitting and control equipment. Solar cell conversion efficiency depends on the maintenance of low cell temperatures in space. An unprotected solar cell, turned to the full fury of the sun's rays, heats up rapidly and suffers a severe loss in operating capacity. To maintain solar cell temperatures at a reasonable level and obtain peak conversion efficiency, Optical Coating Laboratory developed the Blue-Red Reflecting Solar Cell Cover. This cover, a vacuum deposited thin film coated glass window placed between the cell and the sun, increases efficiency by selectively reflecting energy which cannot be converted to electricity. It also protects the cell from electron bombardment and erosion by micrometeorites. The solar cell cover window is just one of many contributions made by OCLI research and engineering to the nation's effort to reach the moon, the planets, and the deeps of space beyond. For further information on OCLI vacuum deposited thin film coatings for space reconnaissance, military surveillance, infrared radiometry, infrared guidance and ultraviolet applications write:

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specific impulse, weights and other parameters—when these systems become operational.

Planning for the future is another of the major functions at Edwards, with the aim to establish propulsion performance goals. Among these are improved specific impulse, availability of cryogenics and tripropellants, reliability and mass fractions.

Since Jan. 1, the group has conducted studies leading to these planning actions:

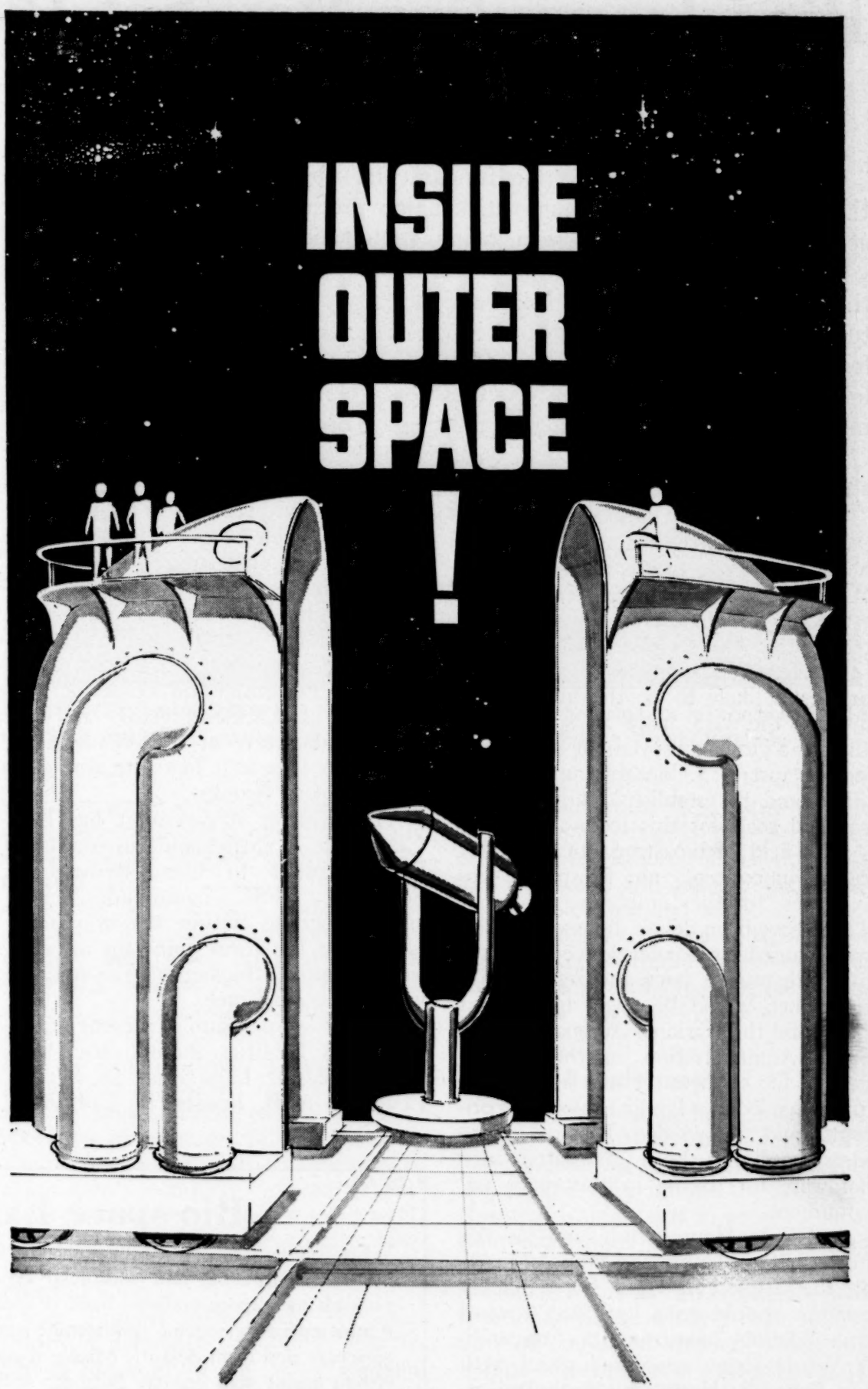
- **Five-year plan** for applied research in propulsion.
- **Rocketry portion** of the Flight Test Center's long range plan.
- **Detailed plan** for rocket test facilities requirements.
- **Ten-year estimate** of chemical rocket production requirements.
- **Propulsion portion** of the Air Force Systems Command applied research planning objectives.
- **Intelligence evaluation program,** in which a procedure has been established to assign propulsion experts from the test group as consultants to the Air Technical Intelligence Center to analyze propulsion data from the Soviet.
- **Summary of rocket characteristics** within the same time frame as study requirement objectives.
- **Summary of development objectives** and applied research for the current fiscal year.

Edwards Group

The Edwards group is one of the principal consultants to the Defense Department and NASA in development of the national launch vehicle range complex. Specific applied research is done in facilities to test systems and components and studies also are made in facilities preparation as they are affected by reliability, multiple sources of data acquisition, operation of test sites involving hazards, toxic scrub systems and altitude simulators.

With its background in propulsion, the 6593rd Group furnishes representatives to 16 formal inter-agency groups and chairmen for three. Chairmen serve on the tri-service solid propellant motors working group, the large solid fuel motor steering committee and the solid fuel motor hard parts working group.

Members are on the Rover coordination group, F-1, Centaur and J-2 technical assessment teams, Air Force-NASA lunar team and the Defense Department advisory panel on fuels, lubricants and propellants. Representatives are on Joint Army-Navy-Air Force (JANAF) panels on physical properties of solid propellants, surveillance, analytics, ignition and static testing, and on the Armed Services Explosive Safety Board and industrial agency management groups.



Or shall we say, outer space goes indoors. However you put it, the meaning is the same: Tenney has brought the exotic hyper-environments of outer space down to earth — and put them into Space Simulators engineered to create, measure and evaluate the effects of extreme spacial altitudes, solar radiation, blistering heat, cryogenic cold and orbital motion. All to assure the safe and certain progress of space exploration.

Tenney's space simulation engineers, with more combined experience than any other company, can help you with your particular project. Write to Mr. Frank Gardner for further details.

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Bioastronautics May Set Pace for Space

Lineally descended from aviation medicine, bioastronautics prepares man for hostile space environment.

Bioastronautics has the same fundamental objective—protecting man in the hostile environment of high altitude, low pressure and unnatural heat and acceleration—as does aviation medicine, from which it is lineally descended.

The environment acting on man and his reactions to these conditions, are the uncertainties in the scientific and military exploitation of space. Structures, materials, instruments and launch vehicles are well into development for interplanetary flight. Man must be equipped to survive launch and re-entry loads and long periods of weightlessness. He must be shielded against radiation and given means to eat and dispose of his noxious waste products. Only then can he be integrated, with sophisticated mechanical systems, into a man-machine space system.

There is little doubt that man will take his place in the spacecraft, but it is ironical that one of the basic conflicts of the space age has centered on bioastronautics. There is growing recognition in the White House, Congress and the Defense Department that bioastronautics is likely to be the field which dictates the U. S. pace in space, and there is a growing movement to centralize the vast U. S. bioastronautics capability, and to establish clearly defined national goals for this technology.

The field of bioastronautics has not lagged in concepts nor in specific approaches to the problems at hand. There have been delays, however, which were caused by top-level decisions delineating precise roles and responsibilities which would be given to the Air Force and the National Aeronautics and Space Administration in the general field of life sciences. The result of this hiatus has been a lag in exploiting concepts and knowledge because these ideas have not been translated into hardware for testing in the space environment.

A White House study and an Air Force Systems Command proposal made at the request of Air Force Headquarters should go a long way toward consolidating bioastronautics research. A White House-appointed panel with Dr. James B. Hartgering, technical assistant to Dr. Jerome Wiesner, President Kennedy's science adviser, serving it as special technical assistant, is expected to recommend a central, national program. Its specific task is to determine whether the U. S. is using its full bioastronautics capability.

AFSC Proposal

The AFSC proposal consolidates all USAF bioastronautics programs into what would be a sixth Systems Command Division, called Bioastronautics. Like four other divisions—Space, Ballistic, Electronics and Aeronautics—Bioastronautics would conduct applied research in carrying a program from concept to hardware. The fifth division is Foreign Technology.

If the new structure is approved, it would result in transfer to AFSC from Air Training Command of the Aerospace Medical Center and School of Aerospace Medicine at Brooks AFB, Tex.; the Personnel and Epidemic Laboratories at Lackland AFB, and the Arctic Laboratory at Ft. Wainwright, Alaska. A Research Institute would be established at Brooks.

The existing arrangement has Brig. Gen. Ben A. Strickland, assistant for bioastronautics to Gen. Bernard A. Schriever, AFSC commander, managing programs within the command. He also is the focal point for information on applied bioastronautics research within the Air Force.

Systems Command's present bioastronautics facilities include the Aerospace Medical Laboratory at Wright Patterson AFB, headed by Col. A. I. Karstens, and the Aeromedical Field Laboratory at Holloman AFB, commanded by Lt. Col. Hamilton H. Blackshear.

One of the early hurdles in the history of bioastronautics, a field which now is 10 years old, was an inability of engineers and physicians to communicate effectively. This problem, now well recognized, has been largely overcome but it resulted in some expensive and time-consuming retrofits because human factors requirements were not considered early enough in systems designs. Doctors are gradually learning the language of the engineer, and engineers are familiarizing themselves with human factors.

The complication of bioastronautics is in its scope—only about 10% of it involves the medical profession. It includes the full spectrum of psychology, psychiatry, electronics and even mathematics, all of which are melded into a technology aimed at designing systems to support and sustain manned space flight.

Joint Actions

With the White House and USAF actions, AFSC foresees a combination of responsibilities and capabilities into a single agency. The possibility exists that unless a consolidation of responsibility and capability materializes soon, the bioastronautics effort will be duplicated and diluted. This problem is fundamental: there are about 2,800 experienced, professional aerospace medical and support people in the military services and they represent more

Bio-space Experiments

Los Angeles—Bioastronautical piggyback experiments are planned for eight launches during Fiscal 1962, and additional experiments will be conducted in Discoverer payloads on a space available basis. Experiments to be flown are:

- **Supercritical cryogenic gas storage and supply system, in an Atlas E scientific passenger pod from Atlantic Missile Range. Objective is to qualify a new gas supply system during zero gravity. Nitrogen will be used in the test.**
- **Biocoustic measurement sensor, in a Thor Agena B, E-5 capsule from Pacific Missile Range. Instruments will give noise and vibration profile of the flight.**
- **Radiation shielding in a vehicle as yet undetermined, to establish parameters for shielding manned spacecraft.**
- **Project GIPSE, meaning gravity-independent photosynthetic gas exchanger in an Atlas E pod from AMR. This system will use algae as a method of oxygen generation and carbon dioxide removal, checking the oxygen supply system during zero gravity.**
- **Passive air regeneration, in an Atlas E pod from AMR, to determine natural diffusion of two gases during zero gravity.**
- **Tissue equivalent dosimeter, in an Atlas E pod from AMR, to continue experiments on the effects of space radiation.**
- **Radiation emulsion in an Atlas E pod from AMR, also a part of the space radiation program.**
- **Bacteriophage, in an Atlas E pod from AMR, to determine reproductive and growth changes in bacteria during weightlessness.**

than 90% of the nation's competence in the field. If NASA builds a duplicate capability, it can be staffed from only one place—which would effectively bleed dry the 31 Defense Department laboratories and facilities engaged in some phase of space-oriented medical research.

An early concern that animal and manned flights by the military would seriously harm international relations has not withstood the test of time. All astronauts who have flown to date are from the military. The Soviet Union makes no candid distinction between military and civilian space programs and all NASA's flight animals have come from the Air Force. None of these factors has adversely influenced U. S. or Soviet images in world opinion.

Current Program

The laboratory-flight program under way in Systems Command's applied research in the life sciences is organized into two broad, interdependent fields:

- **Human factors engineering,** conducted at the Wright Patterson Aerospace Medical Laboratory, with applications and contributions emanating from Patrick, Edwards, and Kirtland AFBs.
- **Biological probes,** the fundamental step which precedes human space flight, conducted in laboratories at Holloman AFB. Animals and specimens will be flown in test systems when it is too risky to send men, or when volume and weight limitations preclude manned flight.

The human engineering programs at Wright-Patterson are geared to advanced manned spacecraft systems being developed and under study, and basically involve all life support components in a sealed cabin.

COMPLETELY IMMERSED in a tank for 6-hr., a subject was tested for his reactions in this simulated weightless condition at Aerospace Medical Laboratory, Wright-Patterson AFB.

Headed by Col. A. I. Karstens, the Aerospace Medical Laboratory is subdivided into three applied research areas: life support systems, behavioral sciences and biomedics. With 200 professional staff members, Col. Karstens has the largest concentration of bioastronautics specialists in the country, and he utilizes them in the complete spectrum of research. His programs include plans for testing components in space (see accompanying box) as payloads launched by the Scout rocket. The fundamentals of the program, however, stem from these major laboratory efforts:

- **Life Support Laboratory:** To determine the tolerance and bodily requirements for man in the space environment, and to protect him from single or combined stresses of mechanical loads, psychological and environmental stresses.
- **Biomedical Laboratory:** To measure the effects of space flight stresses on man, particularly in acceleration, toxic hazards, heat, acoustics, vibration and impact.
- **Behavioral Sciences Laboratory:** To determine means of obtaining optimum performance for both ground and flight crews in system design, operating procedures, training and crew selection.

Indicative of the scope of research activity is the number of programs under way in the life support area. Major research is being conducted in protection, cabin habitability, bionics and bioinstrumentation, and stress tolerances. Emphasis is given to better means of visual observation, full pressure suits for use inside and outside the spacecraft, acceleration and radiation protection, optimum accommodations for habitability, instruments to measure, record and process physiological parameters, and tolerances required during long space flight.

Critical Requirement

The critical requirement for a satisfactory ecological system to sustain the human crew for long periods is being approached in a number of programs. Research is under way in waste reclamation, sanitation, closed ecologies and nutrition.

Col. Karstens sees an immediate need to extend his research to include simulation of combined stresses, which will require construction of a dynamic escape simulator. With this device, much-needed baseline data can be computed for indices for various stress combinations of acoustics, vibration, chemical toxicity and heat.

The multiple effort under way in human performance research at the Aerospace Medical Laboratory deals with the general areas of training, performance and human engineering. Specific performance research programs involve operator and maintenance crew training, training automation, human performance under stress, training simulators and performance instrumentation.

Objectives in human engineering research are to determine pilot ability to

Hare in the Air

Dayton—Rabbit is scheduled to be launched as the payload of a Blue Scout four-stage solid rocket in the most advanced of 10 biomedical experiments planned for flights during Fiscal 1962 by the Aerospace Medical Laboratory at Wright-Patterson AFB.

Called "hare in the air," the project involves instrumenting the retina of the rabbit's eye, which presents distinct indication of the amount of radiation to which the animal is subjected.

Other AML bioastronautics experiments, all scheduled for launch from the Atlantic Missile Range as Blue Scout payloads are:

- **Liquid oxygen converter system, to qualify operation in a weightless environment. Two launches are scheduled.**
- **Expendable-coolant cooling system.**
- **Carbon dioxide reduction system.**
- **Closed chemical respiratory system.**
- **Non-biological respiratory system.**
- **Bio-ecological respiratory system.**
- **Microbial waste treatment system.**
- **Urine recovery system using the pyrolosis technique of burning noxious material.**

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receive information, remotely handle and manually maintain a vehicle, and aids for performance under weightlessness.

The AML program is no different from many in applied research in that much of the technology is considered valid and needs only to be proven in flight. This situation exists for one of the most critical tasks under way at the laboratory—selection of crews for the Dyna-Soar boost-glide vehicle program. The dilemma in this program is historical, because it is always more difficult to evaluate healthy people than those who are sick. One physician at Wright likened the situation to establishing criteria for defining different strata of "perfect."

There is another problem as well in the long training time required for Dyna-Soar pilots. No method exists for predicting reliably how a man who is rated excellent today will react three years from now, yet this sort of prediction is vital in order to obtain the best pilot pool available. Selection, however, is one major area which will continue to be studied, and hopefully improved.

Continuous Evaluation

The laboratory conducts continuous evaluation of all graduates of the USAF Test Pilot School at Edwards. To date, 44 pilots have been assessed under stress from psychological, biochemical and physical standpoints. They have all passed and have been put into three categories, excellent, very good and good. Genesis of the stress program is in the selection process for Project Mercury, which in turn had its foundation in test pilot and special mission selection procedures. Wright has pioneered this selection field and is continually researching the area to eliminate the clinical, occasionally nebulous procedures in it. Working with universities, the laboratory now is developing a battery of objective, quantitative psychiatric tests to replace the interview—the results of which could vary widely among psychiatrists interviewing the same individual.

A bioastronautics program very closely related to that of Wright, but having an entirely new set of problems, is under way at the Atlantic Missile Range at Patrick AFB. The Dyna-Soar Step I mission, which will be flown downrange from AMR, can be conducted simultaneously with Project Mercury, but a pressing schedule problem will exist when NASA's Project Apollo and USAF's Dyna-Soar are both concentrated at Cape Canaveral.

Although both programs are several years away, the problem has been recognized as one which will be solved with precise scheduling. A feeling exists that the optimum situation is a single biomedical manager for all manned flights from AMR.

TYPICAL VACUUM DISTILLATION system for the conversion of urine to potable water is shown above. It would utilize pressure and temperature differentials available within the cabin or from the external environment.

With the buildup certain in the number of manned space flights from AMR, the long-range Cape Canaveral plan has included these working assumptions:

- **Facilities** are required for support from 45 days before launch to a postflight evaluation.
- **One agency** must be made responsible to meet all biomedical requirements, with a common-use agreement.
- **Requirements** will be made by project managers, and it will be the responsibility of AMR to maintain, equip and supply the bioastronautics facilities needed to support all missions.

Col. George Knauf, AMR surgeon, feels it wil be too expensive for each program to have its own medical support, and he believes a saving in manpower and money can be accomplished with a gradual buildup in support facilities at the Cape.

The first of these facilities will be included in the new Patrick AFB hospital, for which funds will be requested in Fiscal 1963. The hospital will include a space medical area. In long-range expansion requirements, but not included in any specific year, are astronaut quarters and briefing and final preparation facilities at the launch site.

The need for these facilities was underscored last month when NASA selected the AMR complex as the site from which to launch its Apollo manned lunar landing spacecraft.

Col. Knauf has developed a Dyna-Soar support plan with facilities based on a 1,200-sq.-ft. prefabricated medical facility which can be set up and ready to use three days after the go-ahead order. This building would be used for immediate postflight medical debriefing, and could be carried to the landing area in a C-130 cargo aircraft.

AMR Responsibility

When manned space flight becomes routine, AMR will be required to accommodate 100-150 astronauts at all times. Col. Knauf said the astronauts will arrive at the Cape fully prepared for their flights and it will be the responsibility of AMR to keep them at their peak.

The new Patrick AFB hospital will be the hub of astronaut care, and other facilities, such as simulators, dietary buildings and operational readiness areas, would be used for final mission preparation.

Since all U.S. manned space flight plans are predicated on evaluation of test flights by monkeys and chimpanzees, the AMR plan includes a requirement for an animal-handling facility. The current requirement is a

Bio-Support Personnel

Cape Canaveral—Requirement for conservation of medical specialists is underscored in the support required for a manned Mercury orbital flight. Total of 166 specialists for this program will multiply several times to meet Dyna-Soar and Apollo needs here.

Total Mercury requirement, including monitors, recovery force and consultant personnel, is 233. Of these, 120 are from the Air Force, 41 from the Navy, 67 from the Army, two from U.S. Public Health Service, and three from the Royal Australian Air Force.

In the recovery force, 80 are medical technicians, 25 general surgeons, 24 anesthesiologists, and the remainder are divided among the rest of the medical disciplines.

Mercury Redstone flights, which have been completed, required a total of 58 medical specialists.

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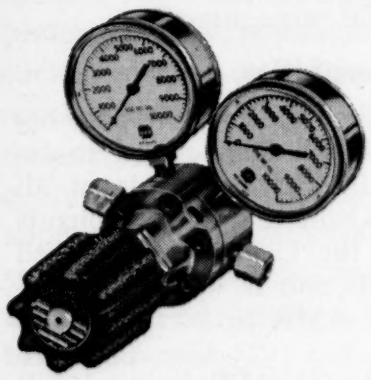

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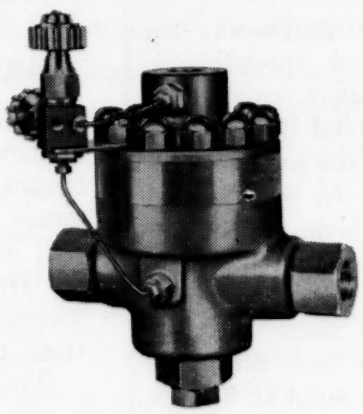

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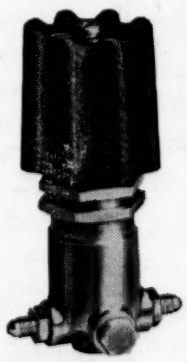

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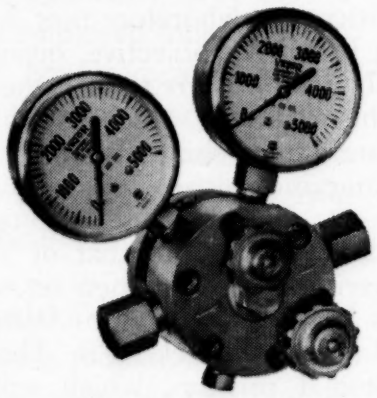

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compromise—the AMR long-range plan is for vans rather than a vivarium to handle primates and biological specimens.

Animals will continue to play an important role in manned space flight missions, although the success of Soviet manned orbital flights are certain to cause a revision in some of the animal bioastronautics research programs.

Short-Term Effects

The relatively short-term effects of orbital flight on man—at least in relatively low orbit—have been demonstrated as being insignificant from the single-orbit flight of Soviet Maj. Yuri Gagarin and from the 25-hr. orbital flight of Soviet Maj. Gherman Titov. The U. S. can call on animals to test life support systems for these missions, but the real effectiveness of animals will be in extended flights of several days, and in orbits of perhaps 500 mi. and higher.

Lt. Col. Frederick H. Rohles, who has conducted the chimpanzee training program at Holloman AFB, said animals can contribute critical information to manned space flights in the areas of:

- **Survival,** by relating to man the performance effects of stresses imposed on primates in noise, accelerations, reentry, heat, vibration and zero gravity.
- **Behavioral effectiveness,** or the ability to perform a task in space learned on the ground.

The best-known contribution of the Holloman facility has been in furnishing the chimpanzee Ham, for the first U. S. Mercury-Redstone flight, and in training six chimpanzees for orbital flights in the Mercury-Atlas program. But this effort also involves mice, rabbits, bears and pigs as well as nine species of primates—all used to probe hazardous environments.

Optimum Animals

Monkeys and chimpanzees are the optimum animals for flight because they can be fitted into couches like man, and they have the same organ suspension as man. Their liver, heart and intestines are in the same locations as man. Configuration of the pelvis and spinal column in a bear is quite similar to that of man, and bears are used extensively in restraint system tests. A pig has the same subcutaneous tissue structure as a human being and is used for impact and deceleration experiments.

The program delves as far as injecting toxic fuels into animals to determine the possible effects on fuel handlers of inhalation of fuel into their systems. One immediate result of this program was a finding that unsymmetrical dimethyl hydrazine (UDMH) produces hallucinations when injected into the blood stream.

Major effort of the Aeromedical Field Laboratory is in the area of chimpanzee experiments. The veterinary services branch, which is the operational unit for chimpanzee training, maintains a colony of 52 of the primates. Value of these animals is indicated by the extent of their training—one analysis placed an average value of $25,000 on each trained chimpanzee.

Chimpanzees are useful in space only if their performances can be measured, and the Holloman group has developed several devices which will reward the animal if its performance is satisfactory, or slightly shock it if it is not. Reward is usually in the form of food or water, and the group has developed a system of feeders and water dispensers which can function in a weightless environment.

Performance tasks are called complex coordination tests, in which an odd symbol must be recognized and quickly eliminated. Simulators with computer links have been developed for this training and the entire colony is involved in preparing to operate these devices in space flight.

Project Snowball

Assignment to Holloman of the Project Mercury chimpanzee program came after the laboratory conducted a series of Discoverer track tests, known as Project Snowball.

One of the initial objectives of the Discoverer program was to build a biosatellite capability in the Agena payload-carrier stage of the Discoverer vehicle. The program was never carried out but Holloman made effective use of its animal training, stratosphere chamber, Daisey decelerator and high-speed track in duplicating the flight profile of a Discoverer satellite mission. The Discoverer Snowball program began in January, 1959, and over the next two years succeeded in general systems checkout and establishing base-line indices for any Discoverer biosatellite flight.

The Discoverer biosatellite program probably was overtaken by time. Critical Samos and Midas reconnaissance satellite components took priority over monkey capsules until the time when the basic question, "Can man survive space flight?" has been answered in the extent that it could be answered in the Discoverer program.

Bioastronautics research in the Systems Command extends also to Kirtland AFB, where the effort is toward determining the radiation hazards to man in ambient space, and providing proper instrumentation to make these measurements. One program involves melting the Tory IIC reactor to determine the toxicity from the Snap-5 type reactor carried in the Transit flight.

Kirtland has devised a tissue equiva-

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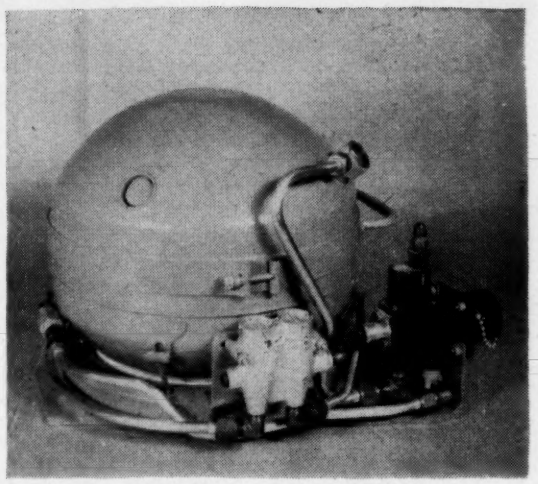

LIQUID OXYGEN CONVERTER, developed by Pioneer-Central Division, Bendix Corp., Davenport, Iowa, uses a semi-permeable diaphragm for positive expulsion of liquid oxygen in a weightless state.

lent chamber which has been carried piggyback on three Atlas flights and on one Blue Scout package to measure the radiation dosages at altitudes up to 1,400 naut. mi. The tissue equivalent chamber has the same "stopping power" as man in that its atomic makeup is the same as that of man. The Special Weapons Center is instrumenting packages to be carried aloft in X-15 flights, and has purchased three plastic dummies designed to correlate tissue measurements with radiation dosages.

The Kirtland flights are part of the USAF-wide cooperative bioastronautics program under the management of Col. E. L. Cole of the Space Systems Division Headquarters. Col. Cole is USAF coordinator for the piggyback flight program (see box) using pods on Atlas and Titan missiles that are undergoing weapons systems development flight test programs.

Col. Cole sees his responsibility as "very much applied research" in life support systems and means of instrumenting animal and human subjects for measurements.

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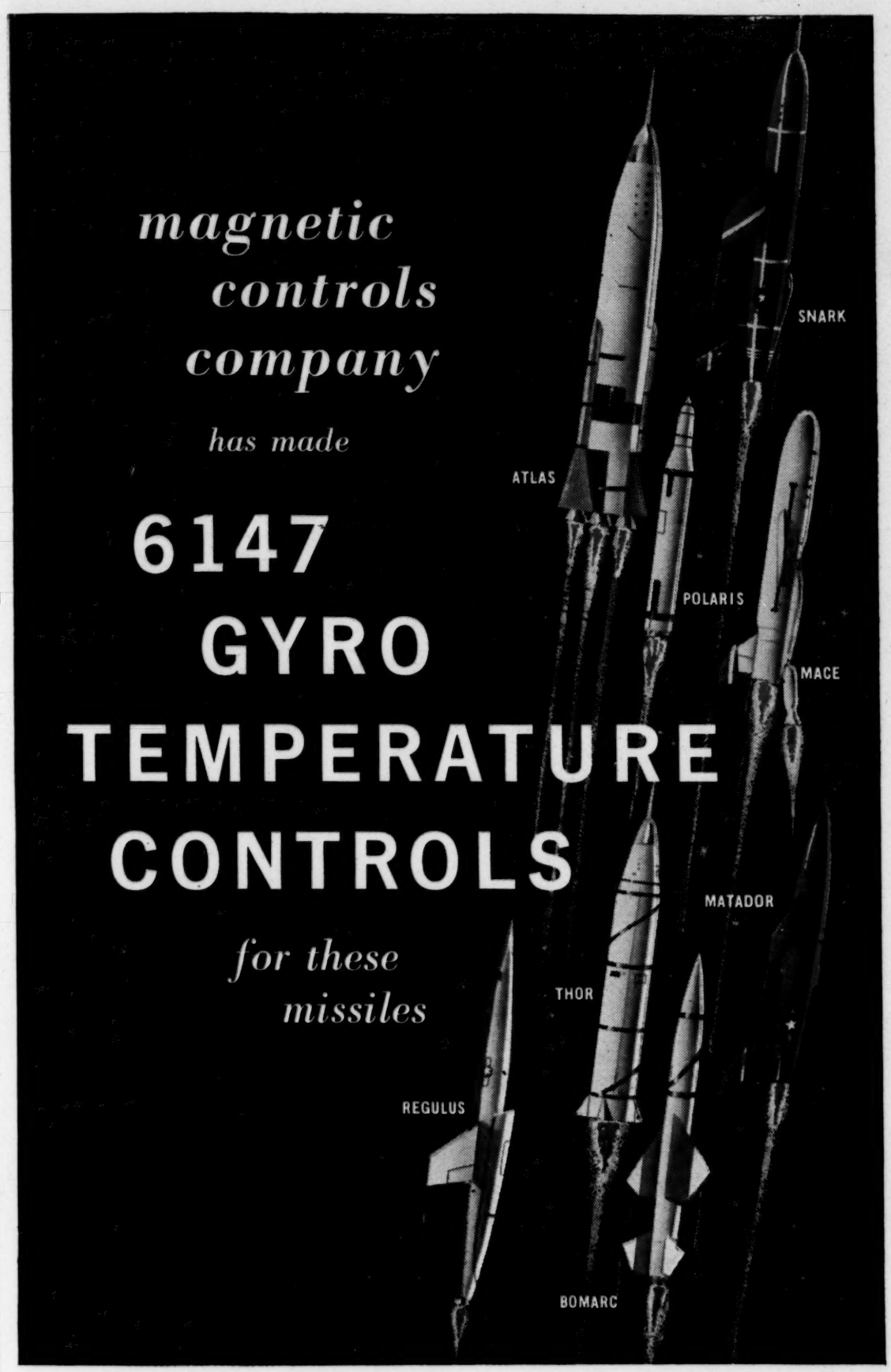

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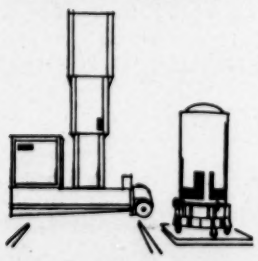

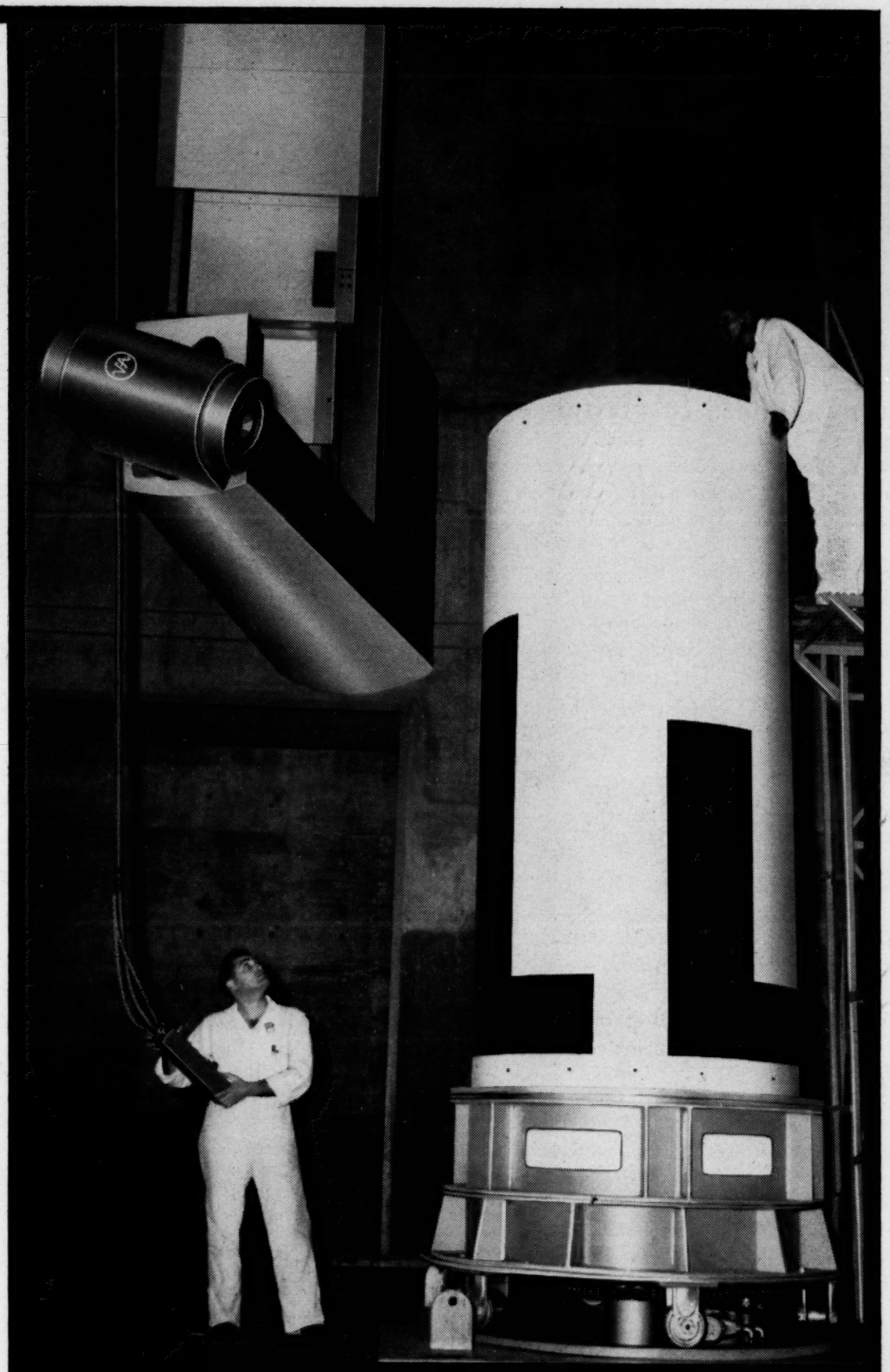

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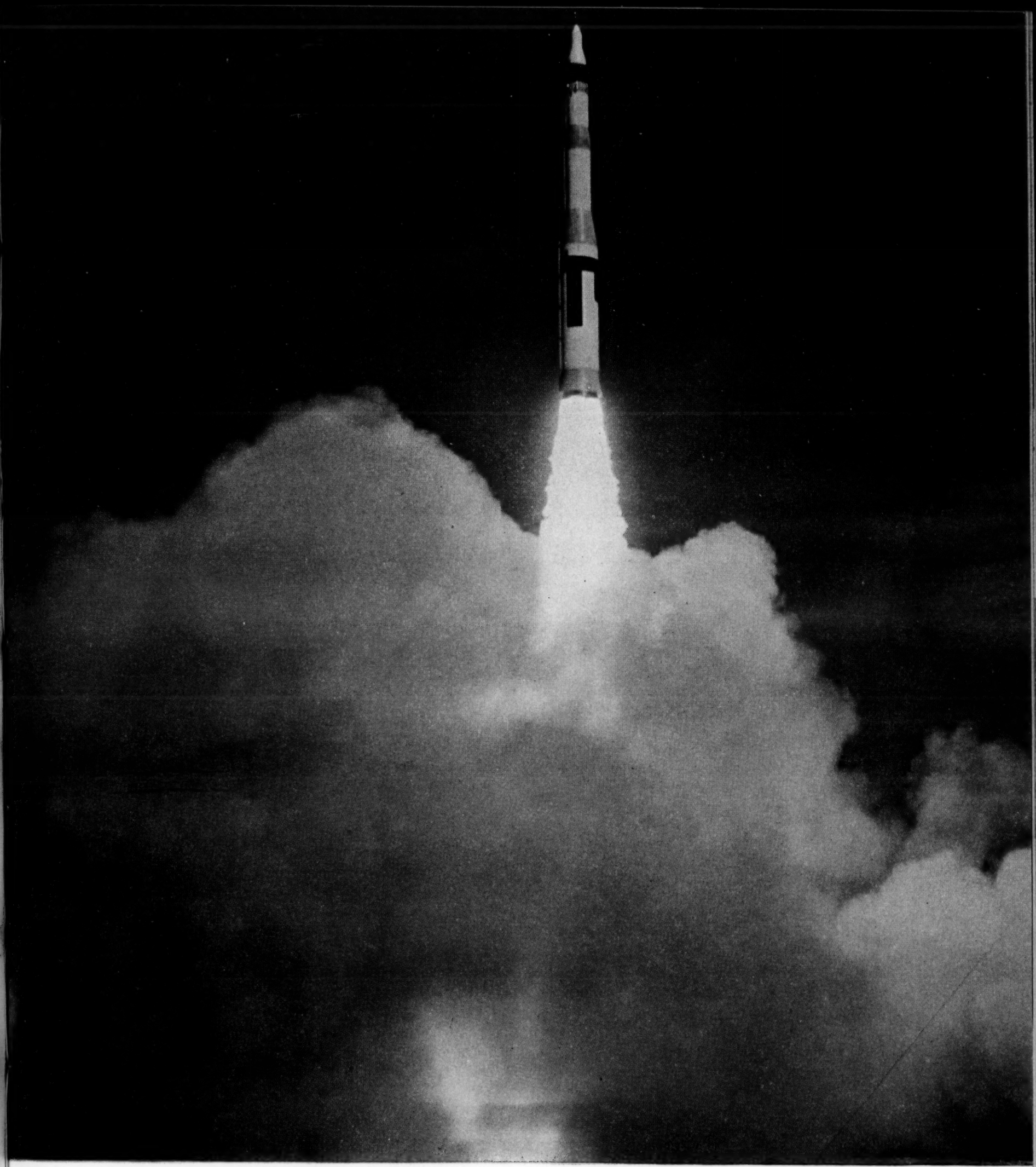

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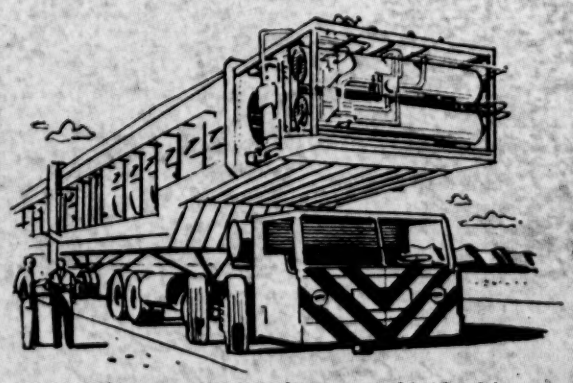

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Ballistic Missile Program Moving Forward

Ballistic Systems Division translates weapon system learning curves into operational sites for SAC.

Inglewood, Calif.—Critical job of the Air Force Systems Command Ballistic Systems Division in readying the United States' top-priority military program—a full intercontinental ballistic missile retaliatory capability—is the translation of weapon system learning curves into operational sites for Strategic Air Command.

From a relatively cold start, the gigantic ballistic missile program has been brought along to a greater operational status than projected by schedules established more than six years ago. Construction peak has been reached and a big job of installation and checkout of equipment lies ahead.

The enormity of the ballistic missile program with all its ramifications is evidenced by this funding summary—$6,845.7 million up to FY 61, $2,774.7 million for FY 61, and $2,552.9 million projected for FY 62.

Commanded by Maj. Gen. Thomas P. Gerrity, Ballistic Systems Division occupies facilities in the Air Force Systems Command's Arbor Vitae Complex, Inglewood, Calif.; at the former Douglas Aircraft plant, Torrance, Calif.; and at Norton AFB, San Bernardino.

Site activation task forces are located at the various missile sites not yet operational. Test wings are located at Patrick AFB and Vandenberg AFB.

BSD personnel in the Arbor Vitae Complex total 952, comprised of 411 officers, 15 airmen, and 526 civilians.

Long-range plan is to move BSD's activities entirely to Norton AFB, a transition likely to be completed after July, 1963. BSD's Norton complement, which now includes Atlas and Titan I project offices and Detachment 1, a support activity, now has a total work force of 417, comprised of 167 officers, 15 airmen, and 235 civilians. This total figure is expected to reach 790 when Titan II project office personnel will have been transferred to Norton by December, 1962, and reach another high of approximately 880 when Minuteman project personnel will have been transferred to Norton in a move scheduled to begin in July, 1963.

Key activities in the BSD organization include system program offices for Minuteman, Titan, and Atlas ICBMs, site activation, technical development, Nike-Zeus office, and foreign technology office.

Minuteman System Program Office, directed by Brig. Gen. S. C. Phillips, has subdivision activities consisting of a configuration control board which is concerned with formulation of specifications for the system and its associated equipment, following through to configuration freeze, acceptance and rejection of change proposals, down to complete system operational turnover to Strategic Air Command and Air Force Logistics Command; a technical staff which provides technical assistance in areas cutting across the gamut of Minuteman organizational activities, and the coordination of the contractor's (Boeing) management of the assembly and test phase for the missile. In addition, the Minuteman organization includes branches for operations, resources and progress control, development, procurement and production, and logistics.

Atlas System Program Office, directed by Col. J. L. Zoeckler, has a similar setup at Norton AFB.

Titan System Program Office, directed by Col. J. L. McCoy, also functions under a similar organization arrangement and has its Titan II activities located at the Arbor Vitae Complex, while Titan I activity already has been transferred to Norton AFB.

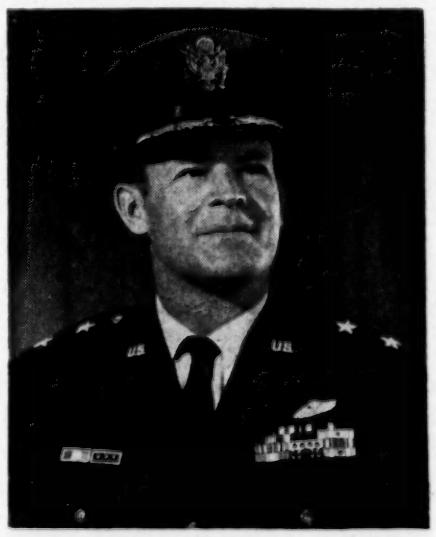
Deputy for site activation is Maj. Gen. A. C. Welling, U. S. Army Corps of Engineers, assigned specifically to the staff of BSD for this job. Charged with the job of preparation and equipping all ICBM sites for operational turnover to SAC, the site activation organization includes facilities design offices for Atlas, Titan and Minuteman, and architect and engineer services procurement branch and an engineering branch. Site activation's Corps of Engineers Ballistic Missile Construction Office (CEBMCO) is staffed by Army Corps of Engineers personnel for a close relationship with the Air Force's Ballistic Systems Division. This office has the responsibility for the construction phase of the ballistic missile programs. An installation and checkout office coordinates equipment integration at the various missile sites and ensures functioning for opertional readiness.

Site activation task forces function directly under the deputy for site activation and are charged with the overall responsibility in the field for activating the particular ICBM sites, including completion of all successive phases to ensure timetable readiness for SAC to take over a completely operational missile system.

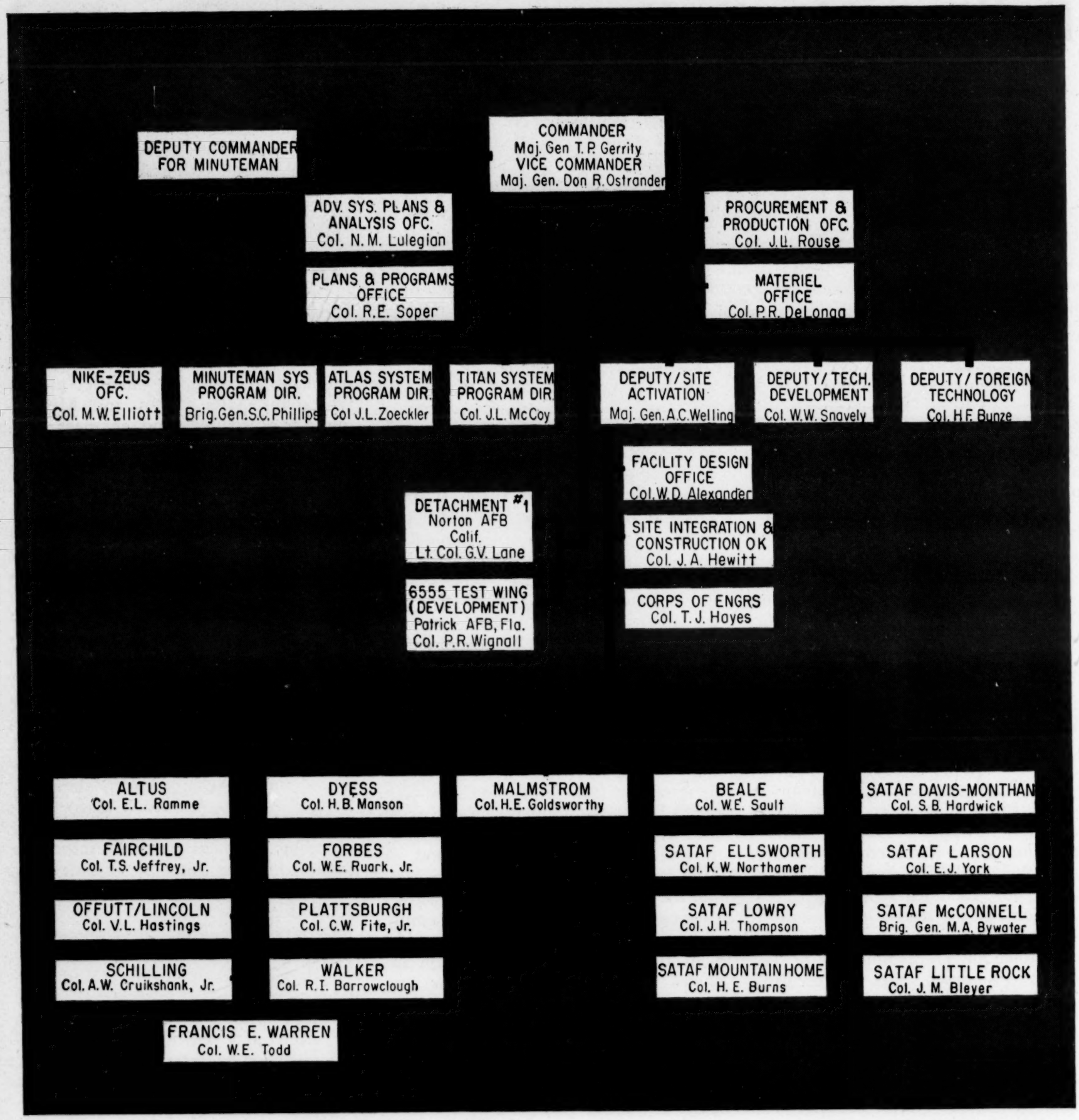
Deputy for technical development in BSD is Col. W. W. Snavely, who has a dual role—that of exploring and evaluating future possibilities for re-entry vehicles, propulsion, communication and electronics, and guidance and control, as well as monitoring development, procurement and production of major subsystems in these categories for current ballistic missile systems.

Deputy for foreign technology is BSD's Col. H. F. Bunze, who is directly responsible to the commander, BSD, primarily for timely intelligence on possible hostile-technology threats and, secondarily, to recommend countermeasures for these threats. Results of this foreign technology intelligence may be applicable not only to new systems under study, but to possible modifications of existing weapon systems.

Nike-Zeus office, headed by Col. M. W. Elliott, coordinates BSD support of missile target requirements in the joint Army-Air Force evaluation program. Prior to the launching of target ICBMs from Vandenberg AFB for Nike-Zeus interception trials, inter-



Maj. Gen. Thomas P. Gerrity, Commander of Ballistic Systems Division, AFSC . . . born Harlowton, Mont. . . . appointed flying cadet, 1939 . . . Philippine Islands, 1941, to 21st Pursuit Squadron, Bataan, March, 1942 . . . Air Materiel Command, Wright Field, November, 1942 . . . Command & Staff School, 1945 . . . chief of Bomb Branch, Wright Field, 1946, to chief of Aircraft and Missile Section, 1950 . . . command of 11th Bomb Wing, 1950, to acting commander 19th Air Division, 1952 . . . Director of Procurement & Production, AF Hqs., 1953 . . . Commander, Oklahoma City AMA, AMC., 1957.



BALLISTIC SYSTEMS DIVISION ORGANIZATION CHART

mediate tests in various development areas will be conducted over the Atlantic Missile Range.

The 6555th Test Wing (Development) based at Patrick AFB, and headed by Col. P. R. Wignall, reports directly to BSD, is responsible for Category I testing of ballistic missiles, which is concerned with subsystem development tests and evaluation.

The 6565th Test Wing (Development) at Vandenberg AFB, under Col. J. J. Cody, Jr., functions under jurisdiction of the Space Systems Division, but BSD has operational control, through the wing's Deputy for Ballistic Systems, of Category II testing for system development tests and evaluation.

The 6592nd Support Wing, headed by Col. W. R. Morton, functions under the deputy commander for aerospace systems, supports both the Ballistics System Division and the Space Systems Division in a "housekeeping" capacity. It provides most of the administrative, logistical, and flying operations support. Where the Aerospace Corp. supplies some of these support operations, the wing monitors the contracts.

BSD's Detachment 1 at Norton AFB, headed by Lt. Col. George V. Lane, has responsibility for the support of BSD programs (presently Atlas and Titan I) based there. Support areas include manpower organization, security, flight coordination, unit supply and information services. In addition, Detachment 1 has responsibility for administrative support for functions of various activities based at Norton in association with the ballistic missile effort. These activities include:

- **Ground Electronics Environment** Installation Agency (GEEIA), headquartered at Rome, N. Y., and responsible for management of ground electronics and communication for missile systems.
- **Air Training Command,** engaged in

the preparation of technical manuals and training syllabuses for operation, maintenance and repair of ballistic missile systems at the various bases.

• **Strategic Air Command-Systems Office,** which has cognizance of SAC's operational, maintenance and logistic concepts and requirements, for advising SAC headquarters concerning deviations and deficiencies noted during design, development, tests and operational phases of Titan and Atlas weapons systems.

• **Air Force Logistics Command,** which exercises an advisory logistics management function in relation to the research and development phase of ballistic missiles, and for the procurement, production and handling of ballistic missile systems, in the operational phase, through direct relationship with Air Force plant representatives and contractors. Another function of Logistics Command here is the tie-in with the Federal Cataloging Program for stock listing of parts.

• **Deputy commander for aerospace systems'** comptroller function, which monitors the funds for ballistic system division contracting.

• **Space Technology Laboratories** personnel associated with systems engineering and technical direction for ballistic missile systems. This group works closely with control and configuration boards regarding engineering change proposals.

• **General Dynamics/Astronautics** personnel, a liaison group between the company and the Atlas Systems Project Office.

Another group at Norton AFB is the San Bernardino Air Materiel Area Office, which supports BSD for Atlas and Titan spares, involving air lift from contractor facilities to test centers (Patrick AFB and Vandenberg AFB) and the operational sites. Air Materiel Area for Minuteman ICBM is at Hill AFB, Ogden, Utah (OAMA).

Bulk of the ballistic missile program is in the refinement stage—in both weapon systems and management aspects. In some instances, development is not yet completed, but preponderance of effort is on testing, production, and deployment of the weapons in the field, and this stresses management.

One management objective which looms large is to concentrate on the efficient performance of the repetitive type of operations from missile site to site, to reproduce the quality the weapon systems need for reliable operation. To achieve this broad objective, BSD has developed a command-managed system involving an efficient discipline of communication and action to ensure the attainment of a learning curve that will produce the end results of quality and reliability, coupled with the equally important objectives of maintaining schedules and costs objectives.

Designated Dynamo, for dynamic action management, the procedure provides a basis for the BSD field commanders to bring problems to the attention of the BSD commander, program directors, and associated personnel, and a technique for solving these problems on a timely basis.

Quick Resolution

The discipline built into this system is aimed at preventing any partial solution or oversight and pushes for a quick resolution of the difficulty. The BSD commander has daily knowledge of the problems in process throughout Dynamo and is able to ensure that all agencies in the command and associated contractors are working aggressively to resolve these problems.

In its general relation to BSD's responsibility for the development and production of the missile, the ballistic missile site construction-engineering job, installation and checkout of equipment for the site, and the responsibility to deliver a satisfactory weapon system on schedule to SAC, Dynamo essentially is "management by exception." In effect, "to sit on the site and hit the operational date," BSD has established definitive milestones, some of which have to be met each week. Dynamo reveals which were not met and how significant are the lapses, and it is with this aspect that Dynamo is most concerned—the exceptions to progress.

Dynamo is unforgiving and inflexible—only the man who initiates the problem, the Site Activation Task Force (SATAF) commander, can display the green light to agree that the problem is licked.

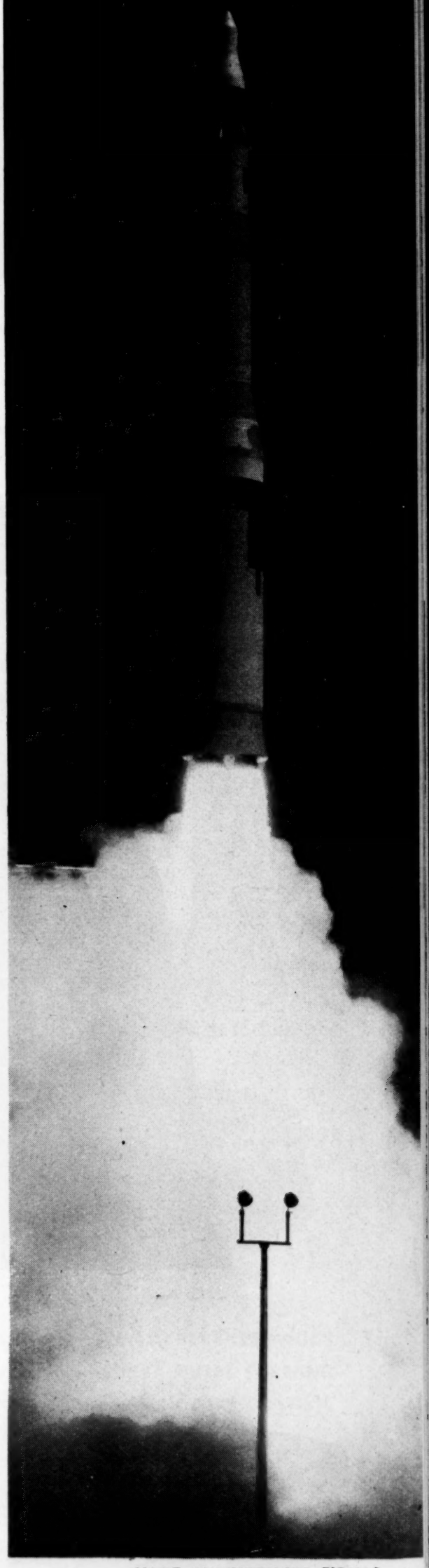
Dynamo categorizes problems into three areas:

• **Bandits.** These are problems which will affect the operational date of the weapons system, hence must be solved at once.

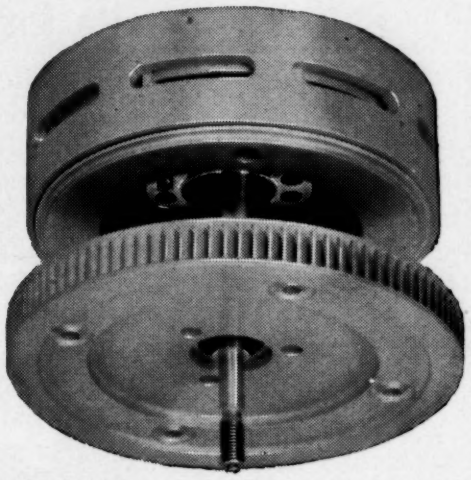
• **Bogeys.** This category includes problems which, if not solved soon, could affect the operational date.

• **Suspects.** These include problems which the SATAF commander can handle himself, but which also will happen at the "downstream" sites.

Problems are relayed from the SATAF to BSD headquarters by an "alert." Most alerts come via telephone, to compress transmission time. Three key officers—for Atlas, Titan, and Minuteman ICBMs, respectively—assigned as controllers are knowledgeable weapon-system men. The particular controller involved executes an alert form which specifies the date and time of initiation, its category (bandit or other), its distribution, initiating



USAF MINUTEMAN FIRING



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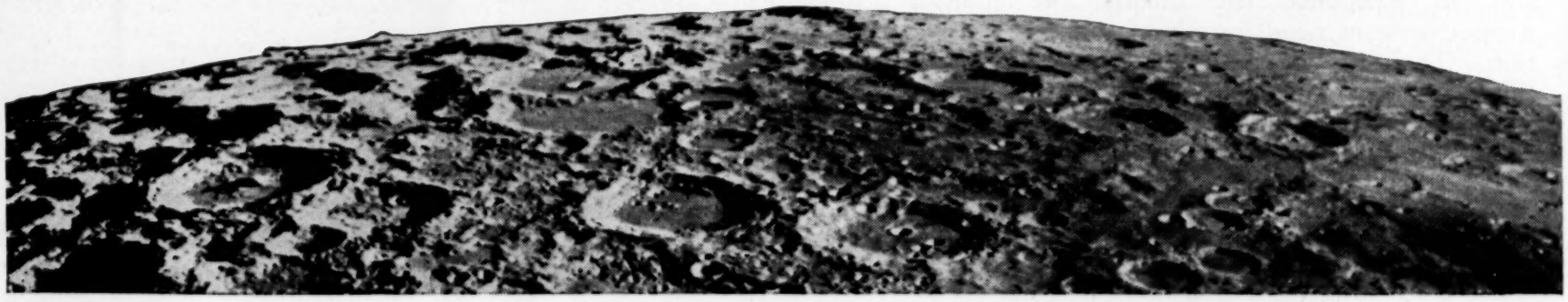

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agency, controller's summary of the problem in one sentence, a yes-or-no check box for operational date danger, description of the problem (in fewer than 50 words), cause of the problem, actual and probable effects, possible remedies, specific action requested by controller and of whom, the base, squadron number and weapon system affected, the milestone description and number, the forecast date to complete the milestone, due date for the initial situation report (SIT-REP) from the "IT," the identity of the IT and special instructions to him.

The IT is one of the respective weapons system specialists who has been appointed by the various system project directors. The term originates from the simple burden-phraseology—"You're IT"—with which the controller passes the job to the pertinent specialist. This assignment sticks unless another specialist voluntarily recognizes it as his problem, in which case the first IT must agree to the actual shift in responsibility.

The IT doesn't necessarily solve the problem himself, but must follow it to the trouble source, which may even originate in another Command. But in any event, the responsibility for the solution to the problem remains with the IT.

Approximately 65 copies of the alert are distributed immediately to all SATAFs and associated ballistic missile program personnel to keep them abreast of site problems.

Depending on the gravity of the problem, the controller demands a report from the IT on a frequency basis —each day for a bandit, every three days for a bogey, and every week for a suspect.

When the IT believes he has killed the alert, he recommends this status, but only the individual who initiated the alert—the SATAF commander—actually has authority to kill it.

Controllers also maintain a matrix chart divided, for a particular weapon system, into airborne equipment, launch equipment, support equipment, "other" equipment, and the relevant contractor and/or agency. There is also an overall alert board in the controller's office and a summary of alerts, according to category, for each weapon system. A display in BSD commander's control room shows the complete status and "building blocks" of the Dynamo system at various levels of detail.

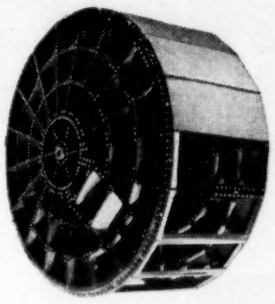
Dynamo was initiated to cover only the weapon system sites, but now is being expanded to the entire ballistic missile effort, for application to R&D and test of the ballistic missile program. Already, Dynamo is in effect at Vandenberg AFB for TF-1, training site for Titan I, OSTF-1 for Atlas E, and OSTF-2 for Atlas F, eventually will

Ballistic Missile Programs' Facilities Investment Through Fiscal Year 1961

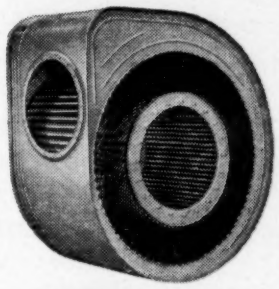
(Millions of Dollars)

	Government	Contractor
Military Construction Program		
Test	195.0	
Training	121.0	
Operational	1229.0	
TOTAL	1545.0	
Industrial Facilities	283.8	198.2
Fiscal Year '61	77.5	
TOTAL	1906.3	
Total Government and Contractors		2104.5

A REPUTATION BUILT ON EXPERIENCE



TIROS STRUCTURE



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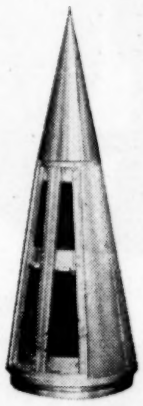

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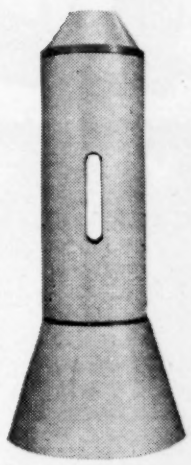

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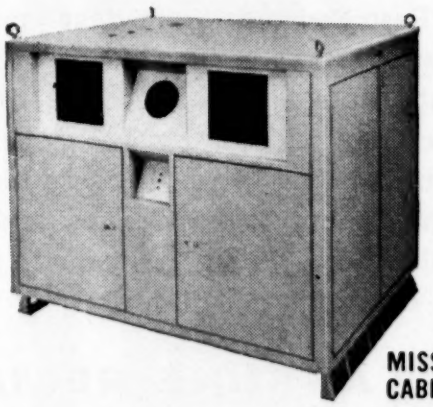

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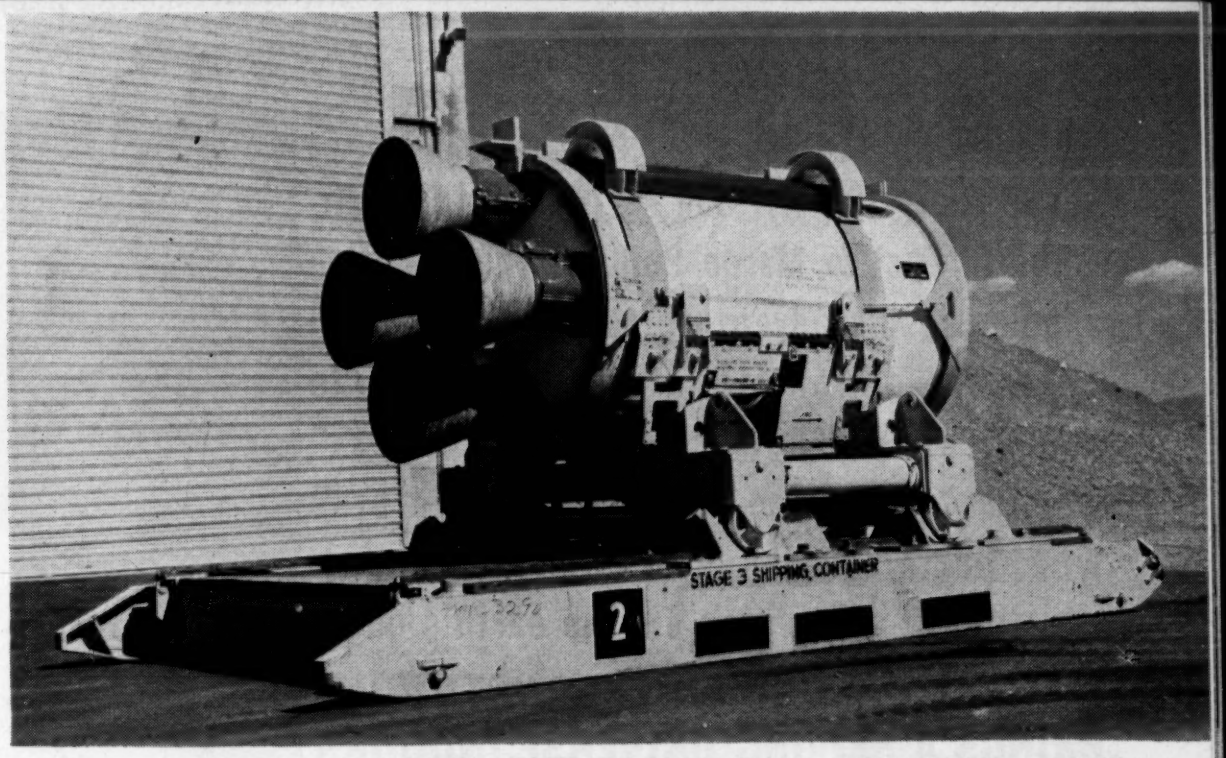
be expanded to all the ballistic missile test facilities.

One of Dynamo's prime progress markers has been the effect of downstream distribution of alerts, which has resulted in a learning curve which reveals that alerts have decreased substantially at the downstream sites.

In the labor area, BSD has been working aggressively, on a continuing basis, toward the elimination of problems resulting in delay. Its attitude, in conformity with Department of Defense policy, has been not to take sides but to press both management and labor to resolve around the conference table jurisdictional disputes and other frictions, meanwhile keeping people on the job. Gen. Gerrity, has not been hesitant to call top labor and management officials when a critical problem has arisen which could cause or threaten work stoppage. Feeling is one of deep satisfaction with what has happened as the result of the President's recent executive order establishing a Missile Sites Labor Commission, and the efforts of Secretary of Labor Goldberg's effort for DOD. Since the Labor Commission has been in effect, work stoppages have been held to a minimum.

BSD is alert to the possibilities of new ballistic weapon systems. Conviction is that there is a potential for developing new ballistic missiles of substantially greater flexibility and efficiency than the Atlas, Titan, and Minuteman.



THIRD STAGE OF MINUTEMAN ON SHIPPING PALLET.

BSD's Advanced Systems Plans and Analysis Office has responsibility for these new ballistic missile concepts and projections. These are communicated to the BSD commander, travel up through the command to headquarters, USAF. The effort is coordinated with Aerospace Corp., which provides technical assistance and supervision for performing these advanced studies.

Potential is seen in all of these areas:

- **The air mobile ICBM** (AW, Aug. 7, p. 52).
- **Ground mobile ICBM.**
- **Advanced hardened and dispersed** ground-based fixed ICBMs.
- **Positive control** bombardment system (a "controllable" ICBM).

The indication is clear that today's ballistic missile program is not necessarily the end of this country's retaliatory capability but is more probably the beginning.

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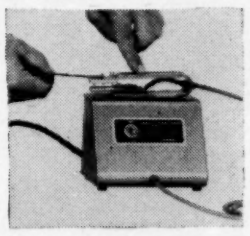

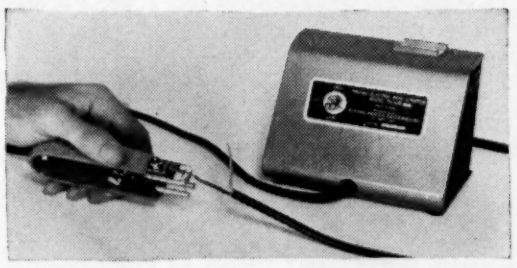

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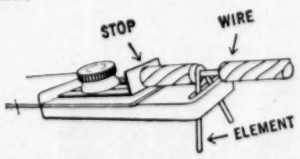

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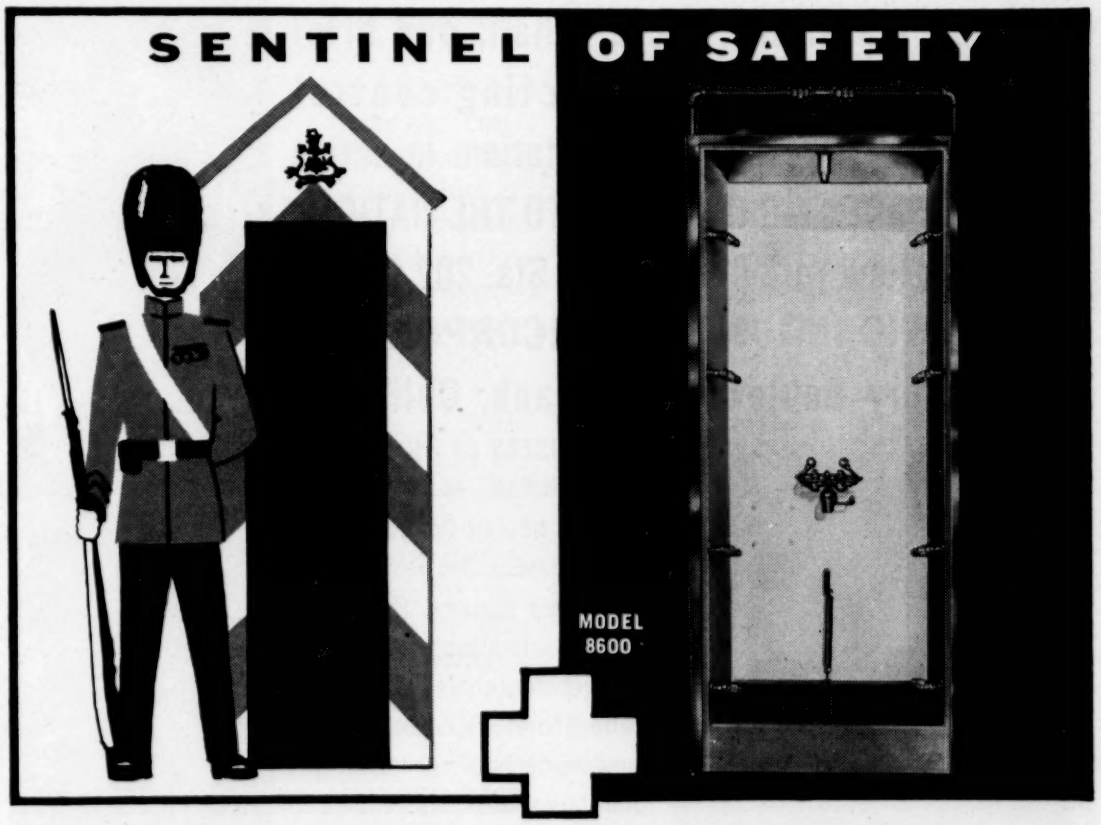

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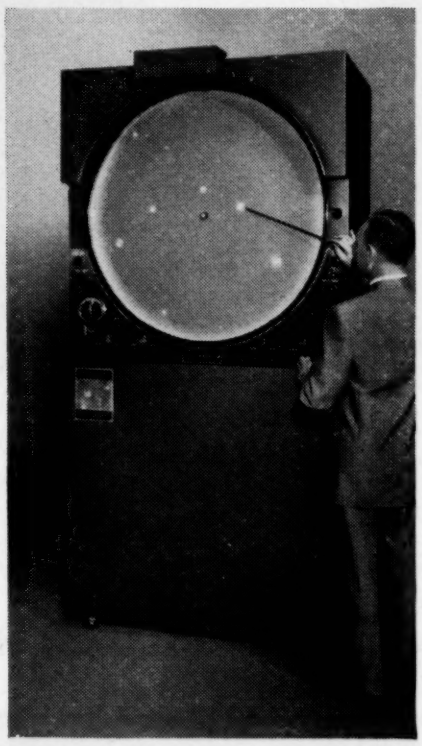

SOME USERS OF THE MUSSER "COPERNICAN" PLANETARIUM... Douglas Aircraft Company, Aero/Astrodynamics Section, Missiles and Space Systems (For demonstrating interplanetary trajectory requirements); Jet Propulsion Laboratory. (For preliminary measurements of spacecraft and planetary relationships, and earth-to-spacecraft communications); American Museum-Hayden Planetarium. (For teaching 19 courses in astronomy and celestial navigation); Adler Planetarium and Astronomical Museum (For demonstrating solar system mechanics and movement of the night sky, in 5 or 6 public lectures daily.)

Circle Number 130 on Reader-Service Card

USAF Pushes Missile Systems State-of-Art

Inglewood, Calif.—Technical Development, one of the key slots in the Ballistic Systems Division, probes the potential of future generation re-entry vehicles, penetration aids, propulsion and guidance and control systems, communications and associated electronics, and monitors current development, procurement and production of major subsystems in these fields for ballistic missiles and specific space systems.

Areas in advanced re-entry vehicle development under investigation include:

- **More efficient** and less expensive ablative type materials.
- **Maneuverable re-entry vehicles,** which might be preprogramed, incorporate terminal command guidance, or terminal target-spotting systems.
- **Advanced arming** and fuzing techniques. These are being studied in relation to the over-all effectiveness of a re-entry system, particularly with respect to minimization of circular error probability (CEP).
- **Improved instrumentation** for re-entry vehicle research and development programs. One applicable area being emphasized relates to precise measurement of the amount of material ablated.
- **Future space systems** re-entry vehicle problems. Magnitude of these problems is indicated by the probable speed of Mach 35 which an earth re-entry vehicle might develop from a far-out space mission, thus introducing difficulties in heat protection for crewmen and pinpoint maneuverability after final orbiting.

In all re-entry vehicle development, close liaison is maintained with the Discoverer project, which is under the control of the Space Systems Division.

In the penetration aids category under re-entry vehicles, goal is to determine and develop devices and techniques required to ensure penetration of a defended target area with the re-entry vehicle of a ballistic missile. This could include devices in categories such as confusion, saturation, tactics (maneuvering). For example, an active jammer would be a confusing device, as would a single decoy, whereas a number of decoys would fall into the saturation category. It's safe to assume that every operational missile necessarily would incorporate some penetration aid for top effectiveness.

The penetration aids program has proceeded concurrently with the ballistic missile program since the latter's inception. Development contractors involved and contributing to the general fund of knowledge include Aeronutronic Division of Ford Motor Co., Avco Corp., and General Electric Co.

Current re-entry vehicle development includes the Mark 11, now in initial development status for later production of the Minuteman ICBM. Development was begun on this re-entry vehicle in December, 1960; the R/V is expected to fly this year on the Minuteman itself, according to present programing.

Before flight tests it will have been, like all other re-entry vehicles, subjected to intensive testing in tunnels at USAF's Arnold Engineering Development Center's facility, Tullahoma, at NASA's Langley and Ames Aeronautical Laboratories, and in contractor facilities, to cover all the parameters of re-entry vehicle performance. Tullahoma, with its pebble-bed heater, simulates high Mach number and high heat simultaneously. Only final flight tests, however, can produce all the realistic and simultaneous effects of a re-entry vehicle plunging in at Mach 22 (roughly 17,000 mph.).

Mark 11

There is no official information available but industry observers believe that the Mark 11 will be lighter than the Minuteman's earlier version Mark 5, and that an improvement in aerodynamic shape may depart from the conventional blunt-nose re-entry configurations. Blunt bodies require longer re-entry periods, experience greater aerodynamic resistance, thus detracting from targeting efficiency. Sharper configurations could re-enter faster, offer a lesser degree of vulnerability and, probably, greater targeting accuracy. Although total heat would be the same in both cases, probability is that heat could be dissipated effectively at local high-shock areas.

Mark 5, on which design was begun in late 1958 as the initial re-entry vehicle for Minuteman, is probably the smallest under development, perhaps half the size of the Mark 3 for the Atlas D. It is an ablative type scheduled for the development tests now on initial Minuteman flights. It also has been carried on two Atlas E flights and one Atlas F flight.

In addition to the ablative material of the re-entry vehicle, there is a light, low-temperature plastic coating (Avcoat) on the nose cone, as well as on the Minuteman body, which burns off progressively during the period extending from silo launch through early portion of the powered flight.

While successive re-entry vehicle development has provided data for improved versions, the Minuteman re-entry vehicle mainly has profited through the use of new, more-efficient, less-expensive, heat-protection coatings.

Mark 6 is the re-entry vehicle for Titan II. Status is in initial development, which was begun in November, 1960, and flight test is expected later this year on Titan II, which is the only missile that can boost this nose cone for the required performance.

No official information on Mark 6 "size" is available, but estimates are that it is roughly twice that of Titan I's re-entry vehicle. Essentially, it is an extrapolation incorporating accumulated know-how.

Mark 4 re-entry vehicle, for Titan I, and Atlas E and F, is nearing the end of its research and development program. It differs from the Mark 3 mainly in size, perhaps may be twice as heavy, although no official information is available. No major changes in the present Mark 4 configuration are contemplated. It is considered to be in initial operational status with Atlas E.

The Mark 3, for Atlas D, was the first ablative re-entry vehicle developed. Development program is concluded, and the vehicle is in operational status, with no major changes anticipated.

Advanced technical development in propulsion applies to specific components or techniques such as feed system dynamics, heat transfer, high chamber pressures, combustion stability, propellant evaluation for higher specific impulses, improved nozzles, lightweight cases for higher mass ratios, internal insulation, and thrust vector control devices. Development generally is weighted on the side of solid propellants, except perhaps for nozzle design and thrust vector control, which might be applied to both liquid and solid propellant motors.

New Techniques

Specific impulses of approximately 270 for solid propellants seem within reach within the next five years. New formulations of chemicals for solids are being investigated, as well as new techniques for mixing these projected "exotics," although this terminology generally is no longer valid for solid propellants. New metal additives also are being studied for producing higher specific impulses. One of these is beryllium, which may have particular advantages in upper stage applications.

Thrust vector control by fluid injection is actively being investigated, including utilization of exhaust gases for this purpose, and regenerative fluid systems. Fluid injection for thrust

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vector control may have limitations in large booster applications because of size and thrust considerations but applications for smaller stages, especially at altitude burning, appears attractive.

Technical Development's efforts in thrust vector control is coordinated with Navy's development, as well as that in industry. Its general propulsion research effort is coordinated with Edwards AFB's rocket test wing, which functions under the Space Systems Division. When research at Edwards appears promising, BSD's Technical Development activity may support it on a development basis.

Propulsion development for existing ballistic missiles includes the M-57 Stage 3, M-56 Stage 2, and M-55 Stage 1, all for Minuteman; YLR91-AJ-5 Titan II sustainer, YLR87-AJ-5 Titan II booster, YLR91-AJ-3 Titan I sustainer, YLR87-AJ-3 Titan I booster, MA-3 for Atlas, MA-5 for Atlas space boosters, and MB3 Block 2 for the Thor space booster as well as other versions for the Thor ballistic missile.

Guidance

Advanced requirements in guidance and control are generated by the operating activities and by Space Systems Division's Advanced Systems Plans and Analysis Office, which generates requirements for both SSD and BSD projections.

A broad spectrum is obtained by gaging guidance and control system sizes, weights, power requirements and accuracies for future developments in relation to industry capabilities. Feeling is that the guidance and control industry is sufficiently strong to meet any foreseeable requirements in the immediate future. Industry observers feel that present circular error probability guidance attainments may be able to be cut in half within the next five years.

No firm development commitments have been made with respect to the next guidance and control system required for weapon system application. Effort is not limited to pure inertial guidance, since it may be desirable to combine radio and inertial guidance in the next development, or inertial and stellar techniques may be combined. Thus, no specific systems have been scheduled yet for the air mobile ICBM or the positive control bombardment system now being considered in advanced planning at Aerospace Corp., technical adviser to BSD and SSD.

Intention of BSD's Technical Development activity is to support effort on sufficient types of guidance and control systems to demonstrate feasible techniques for future applications. This work requires close coordination with Air Force Systems Command's Aeronautical Systems Division, which is responsible for component development. Thus, BSD's technical area coordinator (TAC) must key the division's projected requirements with ASD's technical area manager (TAM).

Meanwhile, advanced development work in guidance and control includes effect of exhaust flame attenuation of transmission and reception phenomena as the result of ionization caused by the flame; and inertial guidance development to improve the state of the art, with particular emphasis on advanced component development in gyros, accelerometers and computers.

There is a continuing program supported at MIT's Instrumentation Laboratory to generate new ideas in inertial guidance. There is no comparable program in the radio guidance category, although there has been a significant improvement in the reduction of size and power requirements for airborne transponders, under industry programs supported by the military.

A geodetic program is under way to determine precise positions of launch points. Participating in this program with BSD's Technical Development activity are Coast and Geodetic Survey and other government agencies.

Current systems responsibilities in Technical Development include radio tracking guidance for Atlas ICBM and space boosters, and for Titan I; and inertial guidance for Atlas, Titan, and Minuteman ICBMs.

Communications

Technical Development's effort in communications and electronics includes responsibilities for system development in intra-site wire communications, inter-site hardened cable-carriers

Advanced development areas include work in interference rejection, magnetic effects, shock isolation, ground waves, and high-speed communications.

Technical Development also has responsibility for various support services which are required by all elements of BSD Systems Project Offices. It is also responsible for the administration of certain contracts by other government agencies such as NASA, and AFOSR, ESD, ASD, and SSD with Space Technology Laboratories.

The activity also satisfies requirements and services common to all elements of BSD.

Technical Development's Activities Test and Instrumentation Directorate conducts liaison between the Atlantic Missile Range and the Pacific Missile Range, as well as being responsible for range safety instrumentation; implements Category I, II and III testing under AFR80-14; consolidates requirements for command destruct systems; and anticipates range instrument requirements for future system testing.

BSD's Deputy for technical development is Col. W. W. Snavely.

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UNLOADING MINUTEMAN FIRST STAGE FROM VAN

Minuteman Targeted for 1962 SAC Use

Inglewood, Calif.—Geared to an accelerated program which will lop a year from the operational projection established when the system was approved in 1958 and several years from the original estimates, the Minuteman ICBM weapon system is targeted to have its first unit operational with the Strategic Air Command in 1962.

The 57-ft., three-stage, solid-propellant missile is being put through a development test program which indicates that it will meet or exceed its performance requirement. Training program details already have been initiated so that SAC crews can be trained with launch and facilities procedures next year at Vandenberg AFB.

The weapon system program is keyed to a very rapid force buildup in keeping with the system philosophy of sufficient strength to meet strategic force requirements. Department of Defense has authorized deployment of Minuteman wings in four areas—near Malmstrom AFB, Great Falls, Mont., the first operational site, where ground was broken this year; Ellsworth AFB, Rapid City, S. D.; Minot AFB, Minot, N. D.; and Whiteman AFB, Sedalia, Mo. Other Minuteman sites are being considered for different locations in the U. S.

Advanced Studies

Minuteman isn't a frozen program. Although the weapon system will be the backbone of the strategic force for a number of years, advanced studies undertaken with Aerospace Corp. envision technologies ahead to anticipate possible block changes in requirements which may be desirable in two, three or four years, while the production program still is under way. This approach will keep the development abreast of advancing technology—"We don't want to be 'cast-in-concrete,' " as one Minuteman spokesman puts it.

Development flight test program for Minuteman is being conducted at Patrick AFB, over the Atlantic Missile Range. Launchings may be expected to progress at a substantial rate in the future.

Initial flight testing was from a surface pad but will be continued from an underground silo to produce operational environmental conditions. Development testing so far has indicated achievement of objectives, has revealed information necessary for the release of production drawings. It is expected that development tests at Patrick may justify sufficient technological forecasts to make adjustments in the Minuteman program.

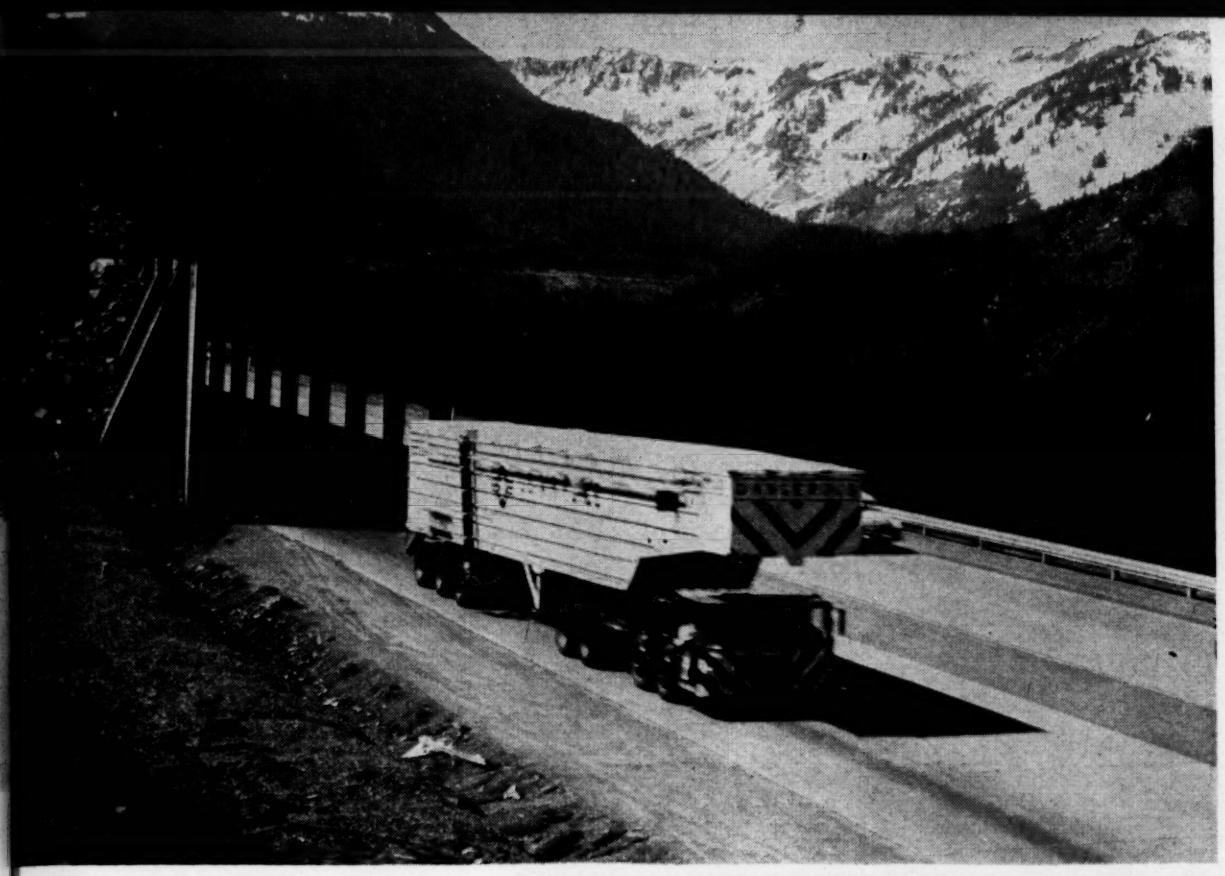
BRIG. GEN. SAMUEL C. PHILLIPS
MINUTEMAN PROGRAM DIRECTOR

To ensure concurrent achievement of schedules, complete systems tests of ground equipment will be conducted at a Boeing-operated Air Force Seattle facility, which will include a launcher and launch control center in the operational configuration.

Statistical Confidence

The number of missiles in the development program is directly keyed to the statistical confidence desired to be generated for the system. Some fairly reasonable estimates regarding the confidence level desired have been established, using the experience gained with the Thor IRBM and Atlas ICBM for background. For example, initial phases of Minuteman tests involved firings from an underground silo at Edwards AFB. The program involved 18 full-size missiles, but when six firings had been made—all successful—this program phase was re-evaluated. It was decided that if two more successful shots were obtained, this phase of the testing—to prove compatibility of missile launch from a silo—would be terminated. The two succeeding launches were favorable and this program phase was terminated at the end of the eighth launch, the accumulated data having verified silo diameter requirements, distance required from bottom of missile to bottom of silo, degree of insulation necessary, and heat rise and decibel factors.

A Minuteman wing consists of three squadrons of five flights each. Each flight incorporates 10 silos and one launch control center. This gives a strength of 50 Minutemans for each squadron, 150 for each wing, plus 10 launch control centers. Minuteman



MINUTEMAN TRANSPORTER-ERECTOR ON ROAD TEST

operational silos are designed for single-shot use. Only slight modification has been required to refine the training and development silos at Vandenberg AFB to accommodate multiple firings.

Simplicity is the key to deployment of the Minuteman weapon system. Reaction time is very fast, dispersion-survivability factor is high. The Minuteman site encompasses only about two acres. Silo is approximately 88 ft. deep, 13 ft. dia. Equipment room surrounding the top of the silo is about 32 ft. deep, has a diameter of about 30 ft. The silo's sliding cover doors are more than 4 ft. thick. An access shaft leads from the surface down to the equipment room. A launcher support building relatively close also is deployed below ground. Very small amount of ground equipment is required in comparison to other ICBMs. A surveillance antenna for the facility protrudes from the area's surface. Weapon system hardness exceeds 300 psi. A highway running by the facility would connect it with other sites in the area via truck transportation.

Launch Control

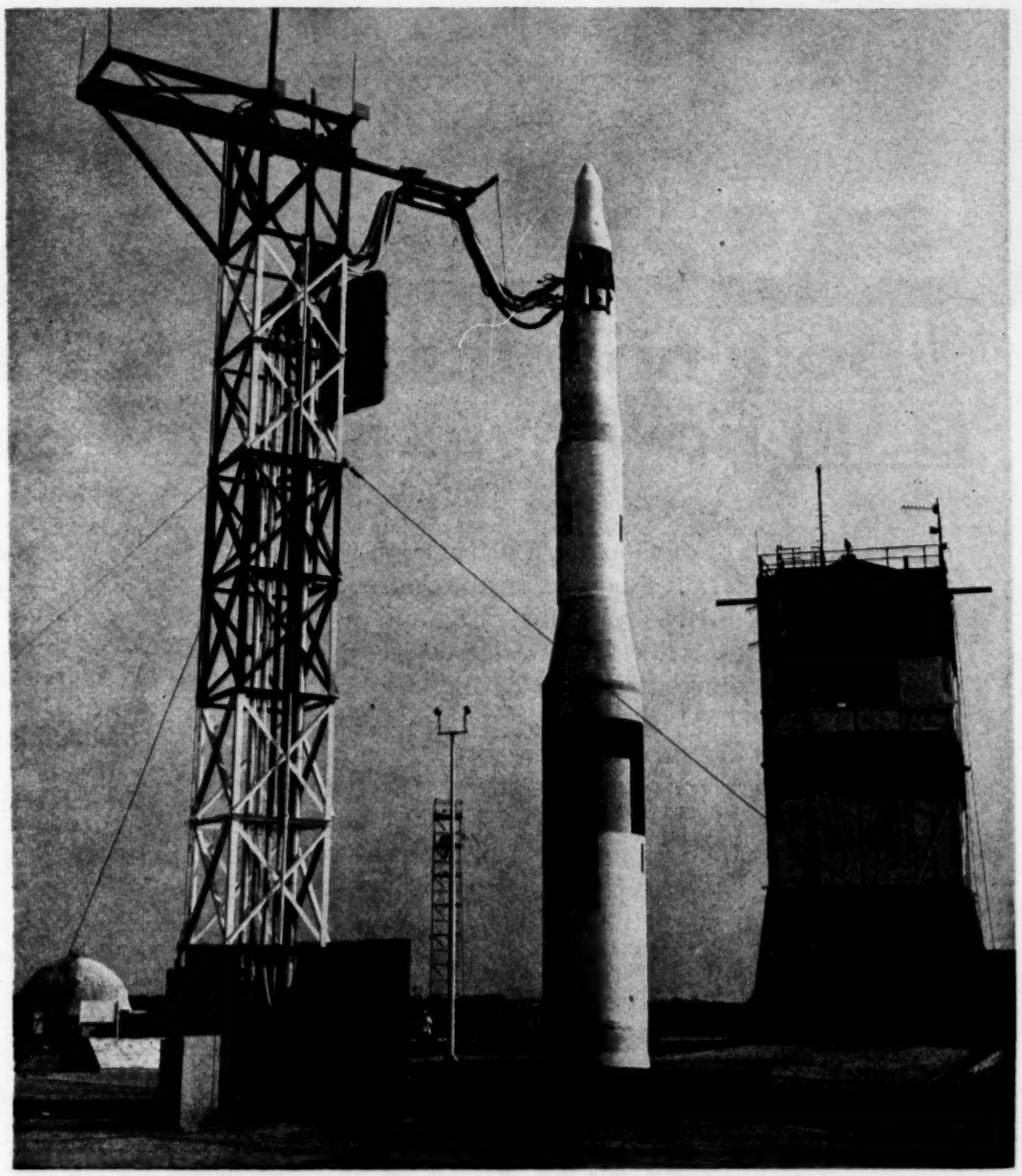
The operational launch control center (LCC), located at a distance from the missile site, is hardened to a greater degree than the missile facility. This underground LCC is fitted with an access shaft to the surface and an additional escape hatch. The center will be manned around the clock, will be in continual communication with SAC's command and control network. The Minuteman LCC will be staffed by less than five but more than one controller, probably two. Associated with the launch control facility is an underground antenna. On the surface there are soft support-buildings to house a small kitchen, bunks to accommodate maintenance teams which have to remain overnight, as well as SAC security troops who will police the sites as required.

The mobile version of the Minuteman missile is under limited development, because there is no firm operational schedule. If Department of Defense authorizes implementation of the mobile system, feeling is that an operational version could be developed quickly. The missile launch car, in which the missile is carried in a strong-back container, is far along the development road. In addition to the launch cars, there are command and power cars for the mobile system.

Minuteman's first stage—5.5 ft. dia. —is the largest solid propellant engine yet flown in the free world. All three stages use four movable nozzles for thrust vector control (TVC), because the various technically feasible schemes studied at the time the design was laid down indicated that the movable nozzle had the highest efficiency in relation to the attainment of design range with the payload the missile had to push. Other TVC devices such as jet vanes, auxiliary thrust units, etc., would have resulted in lower performance efficiency.

A package control system, located at the base of the engine, receives its intelligence from guidance and control compartment on the head of the missile and translates it into nozzle movement for pitch, yaw and roll.

Guidance and control system is a departure, in some respects, from past



MINUTEMAN ON PATRICK AFB PAD

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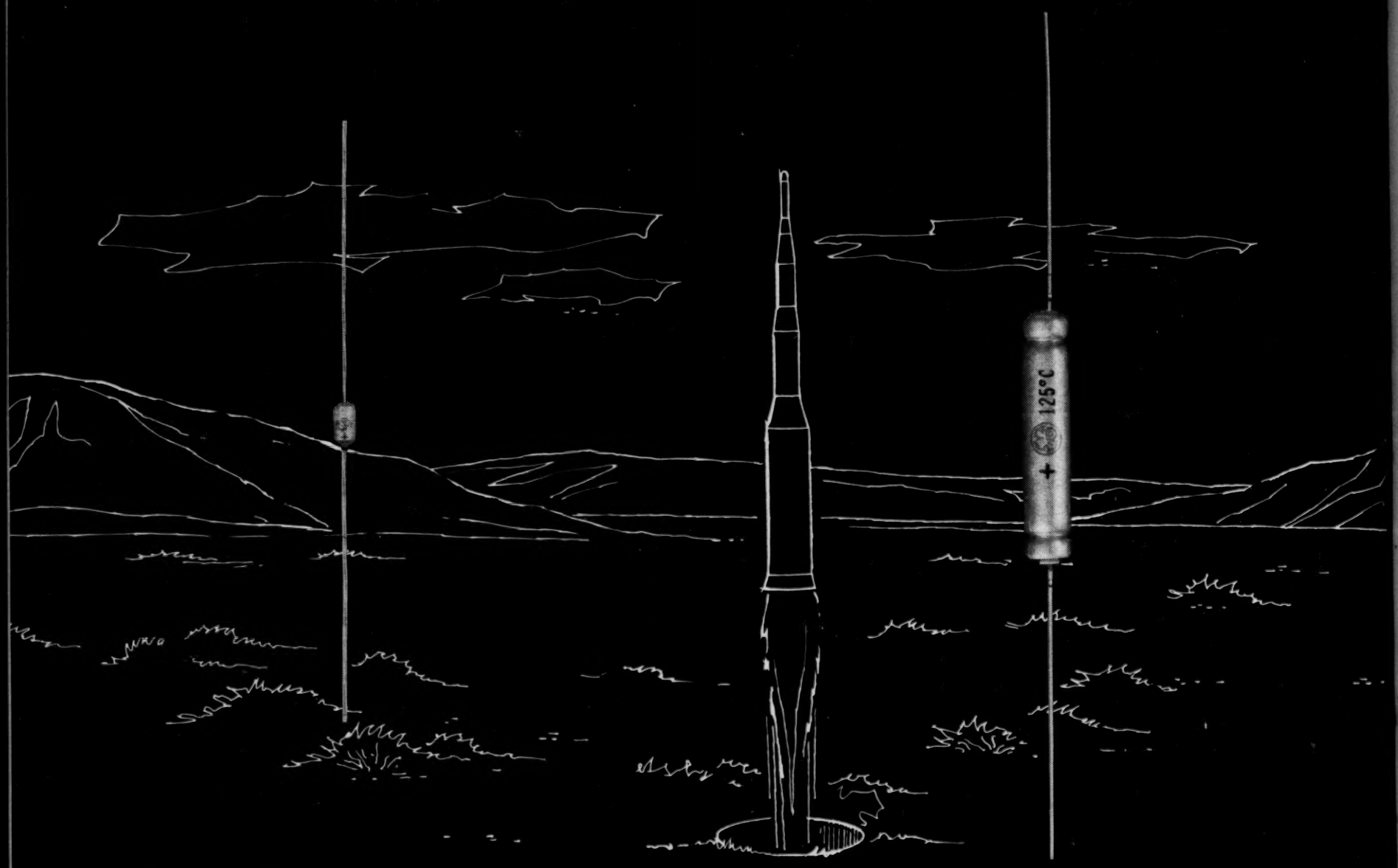

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practice. It is integrated to use one set of inertial references—a stable platform which gives a particular line of vertical and a particular line of azimuth for both control and guidance.

The missile uses only one computer —a general purpose digital unit—which provides trajectory computation in flight. It also provides whatever memory and intelligence the missile requires for strategic alert and countdown.

For launch, the silo door is moved back, the first stage is ignited and the missile flies out under its own power. It emerges in less than one second, has to withstand high heat, and decibel levels which are translated into vibration.

Minuteman has a very rapid acceleration, since its thrust/weight ratio is sizable—rated thrust is 260,000 lb., launch weight is 65,000 lb. Approximately three seconds after first stage ignites, the missile is programed to pitch into its climb angle then, under control of its guidance system, climbs and accelerates as it is corrected for the proper trajectory. The powered portion of the trajectory is small in relation to the 5,500-mi.-plus range.

The missile has a graduated layer of sprayed-on ablative-plastic insulation over its surface to protect it from the launch heat generated in the simple cylindrical ductless silo, and against aerodynamic heating during powered flight in the atmosphere. Heaviest coat of insulation is at the base of the missile. As the ablative type material vaporizes, the missile weight decreases. Theoretically, the ablative insulation should disappear completely when the missile leaves the atmosphere.

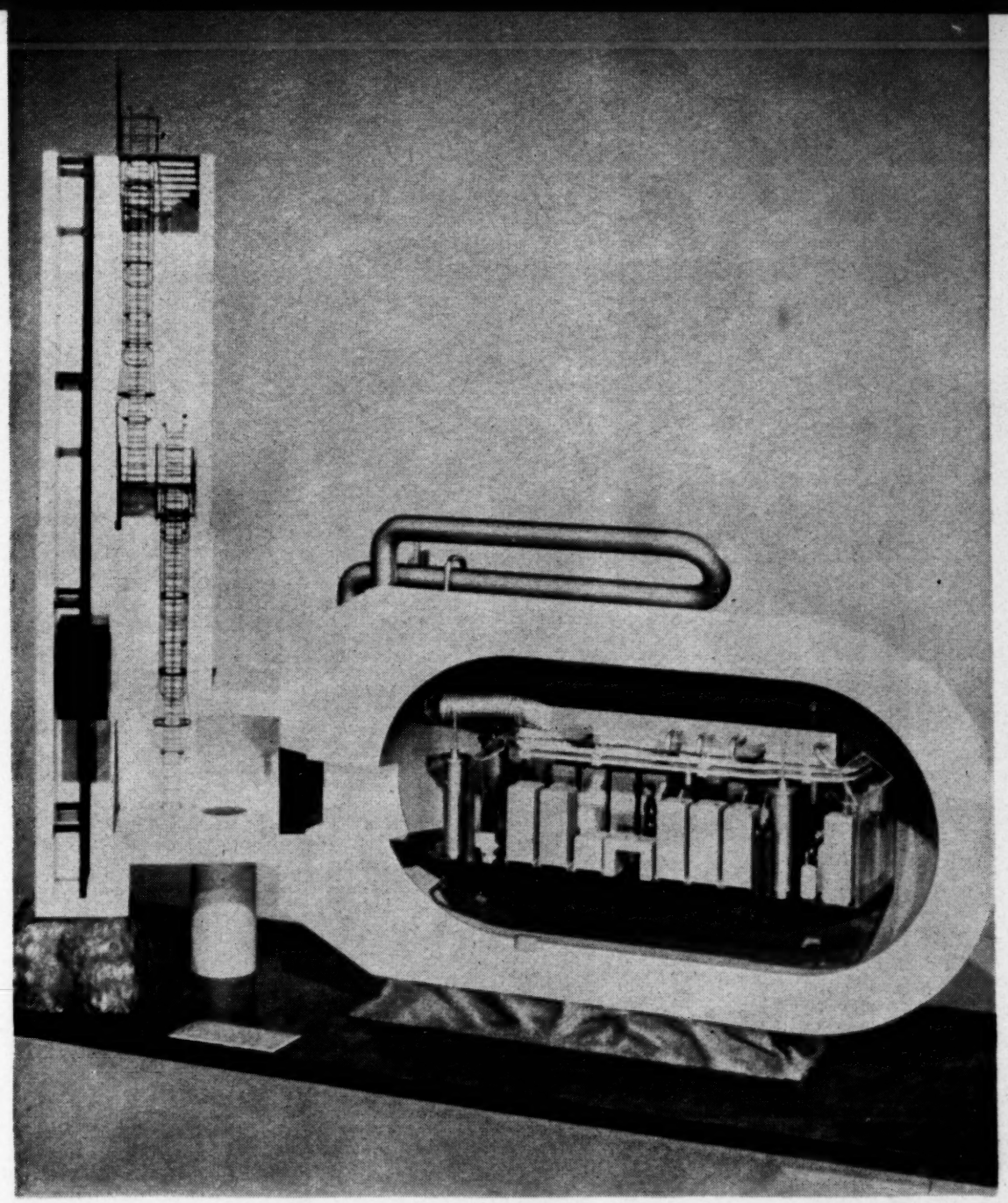
When the first stage is nearing burnout and thrust is falling off, this is sensed, at a certain level, by the guidance system, which initiates the staging sequences for separation to occur approximately midway on the interface structure between stages 1 and 2. With stage 2 burning, acceleration again rises rapidly. The staging sequence is repeated for stages 2 and 3, and near the end of stage 3 burnout, the missile is "looking for a final speed." The guidance and computer measures the speed and seeks a value when the speed to be gained is zero. When the computer determines that this programed speed has been reached, thrust is ended by thrust-termination ports located on the side of the third stage, the re-entry vehicle is separated and continues along the trajectory in free flight to the target. Guidance and control and computer equipment remain with the third stage.

Minuteman uses the Mark 5 re-entry vehicle, while a more advanced version, the Mark 11, is under development.

The Minuteman concept achieves a much closer relationship to mass production than was technically feasible with the earlier ICBM systems. The system can be built at a fraction of the price of earliest ICBM systems and its design permits relatively low operating costs, requiring a minimum number of people for maintenance and operation. Another feature of the development is that a maximum amount of testing is conducted in the factory environment, so that the system can be put into the field on a production basis instead of performing some of the engineering in the field where, in the case of other ICBMs, some equipment is encountered for the first time.

Critical factor in the achievement of low operating costs is the aggressive reliability program that has been pursued for Minuteman. One example is in the area of electronic design, which stresses basic design simplification and drastic derating of individual parts, in some cases as low as 10% of the normal threshold. Also, a benign environment is assured for each part. Solid-state devices are used exclusively, and only fixed resistances are employed. Use of relays is avoided, single-sided circuit boards are used, and different-parts types are minimized. All these design details apply to ground equipment as well as airborne equipment.

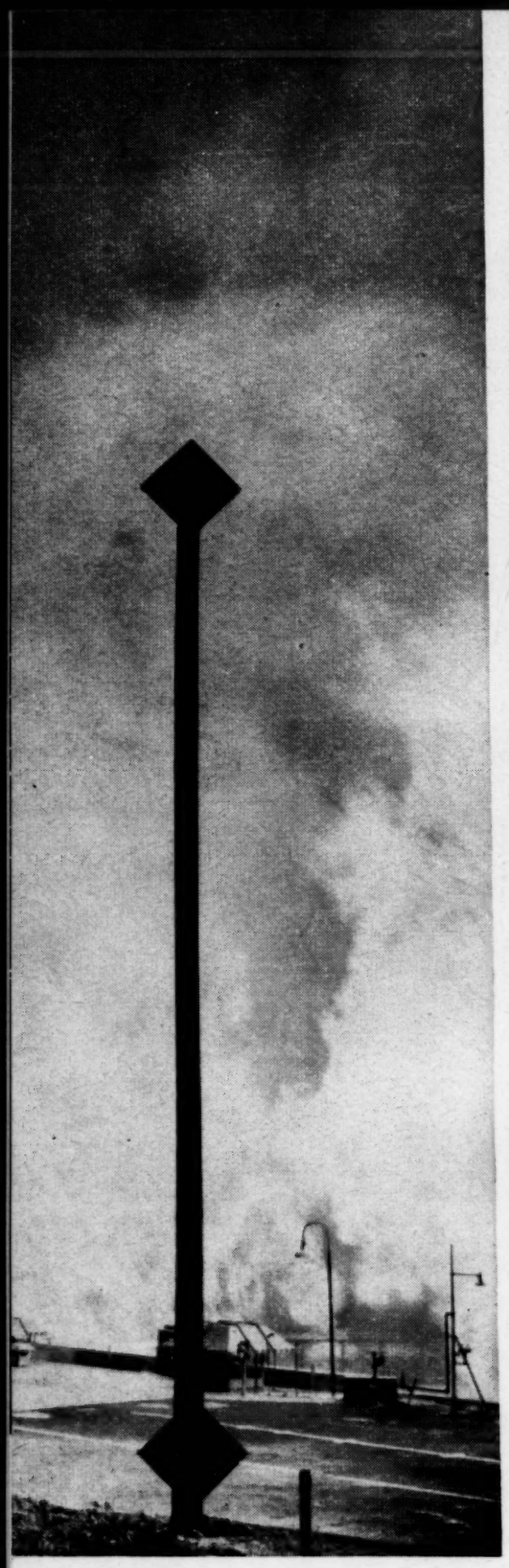
Minuteman system program director at Ballistic Systems Division is Brig Gen. S. C. Phillips.

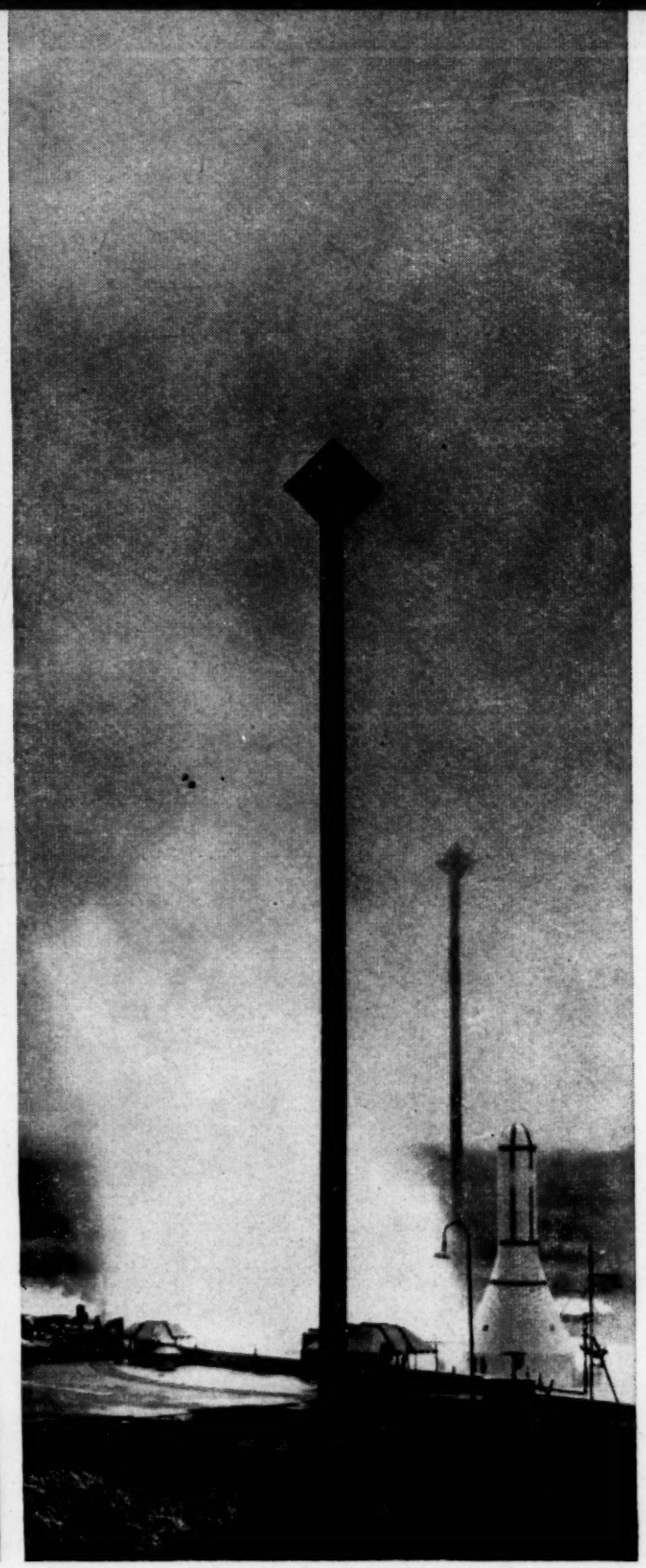


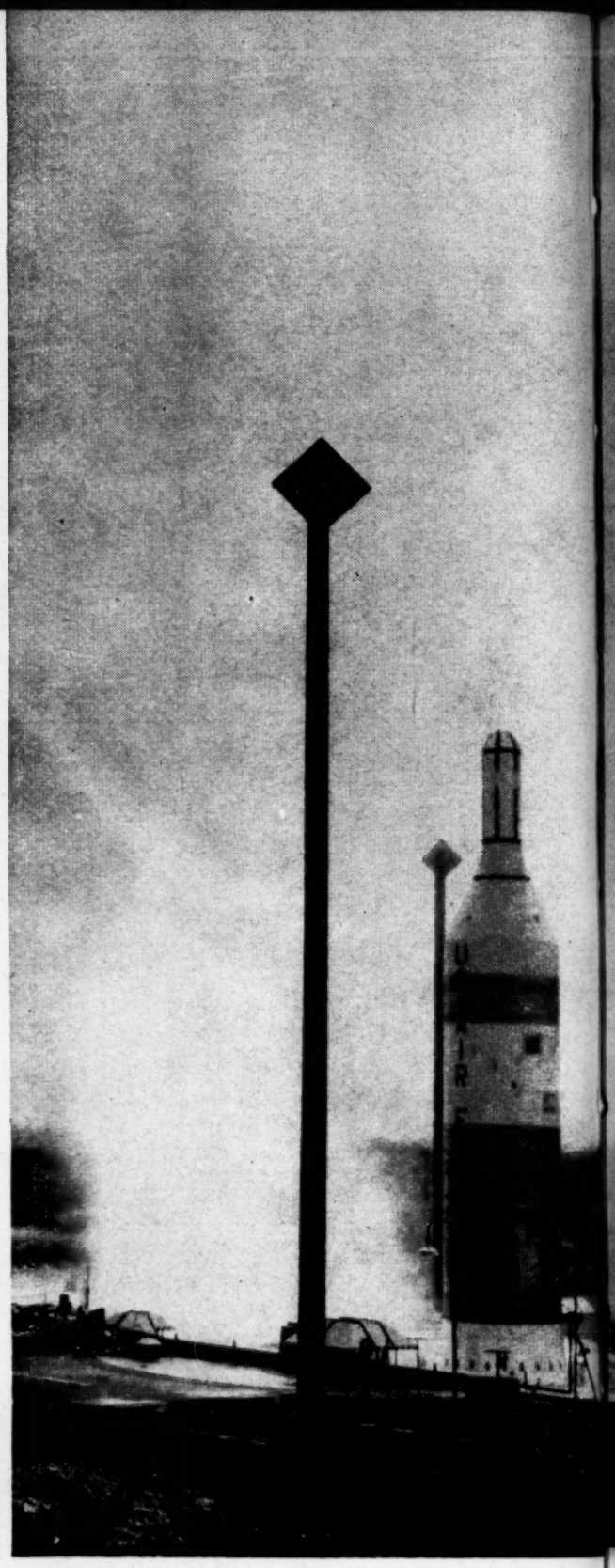
MODEL OF MINUTEMAN SILO AND LAUNCH CONTROL CENTER

Minuteman Contractors

Airframe, Assembly and Test	Boeing Co.
Propulsion	
First Stage	Thiokol Chemical Corp.
Second Stage	Aerojet-General Corp.
Third Stage	Hercules Powder Co.
Guidance	Autonetics Division, North American Aviation Co.
Re-Entry Vehicle	Avco Corp.
Architect and Engineer	Ralph M. Parsons Co.
Systems Engineering & Technical Direction	Space Technology Laboratories







TITAN I was successfully fired from a Titan II silo at Vandenberg AFB, Calif. earlier this year. Objective of the test was to determine

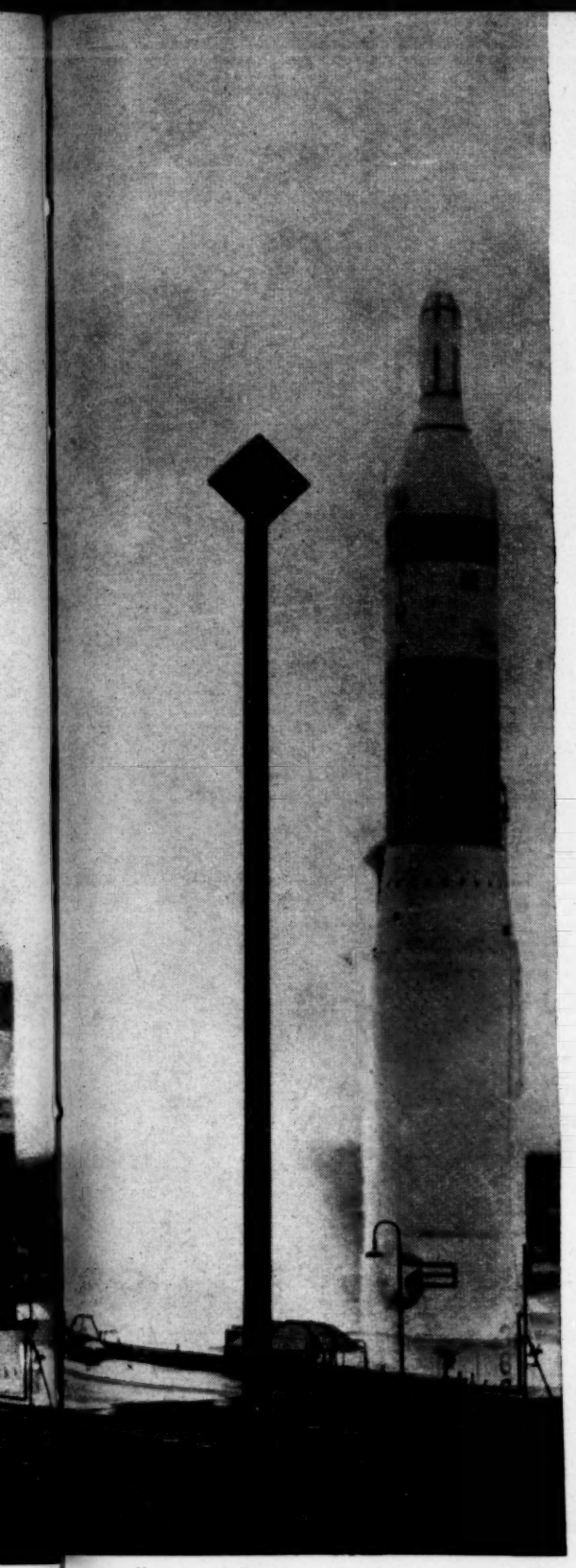
Titan II to Give USAF Well-Protected

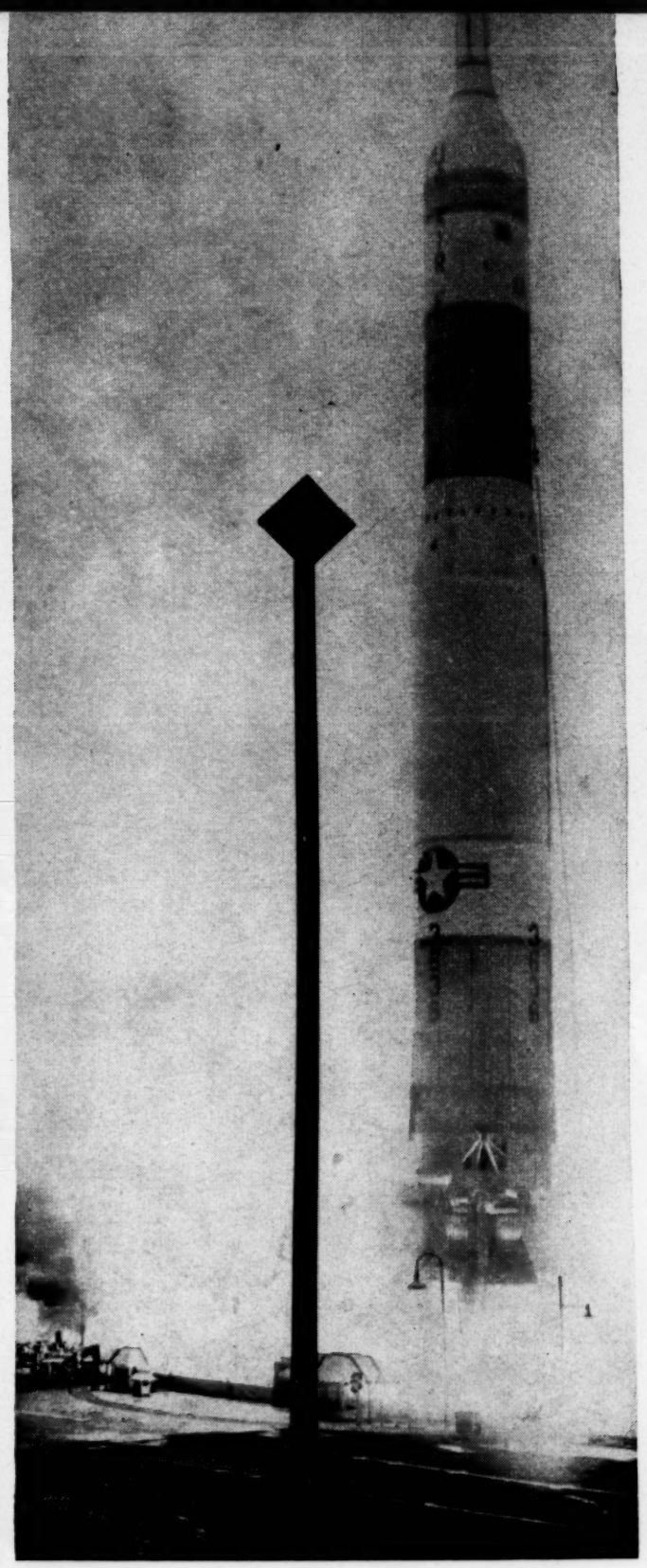
Inglewood, Calif.—Initial operational complexes of Air Force's Titan II, advanced liquid-propellant ICBM to be launched from hard, underground silo sites, are scheduled to be turned over to Strategic Air Command between January and July, 1963.

Titan II is seen achieving a total balance of operational effectiveness based on specific improvements, which, when consolidated into a weapon system, result in a cost per squadron substantially less than that achieved with the earlier Titan I squadrons. Range exceeds 5,500 naut. mi., with a heavier warhead than Titan I.

Firing of a Titan I from a Titan II silo launch test facility (SLTF) at Vandenberg AFB last May (AW, May 8, p. 30), the first time a liquid-fueled ICBM had been launched from an underground silo, established the feasibility of the technique, confirmed the validity of Titan II calculations and previous one-sixth-scale testing at the rocket engine manufacturer's (Aerojet-General) Azusa, Calif., facility with respect to launch environment associated with below ground firing. Measured temperature levels matched, in all instances, the predicted values. Measured decibel levels—critical for control of potentially destructive vibration—also were identical with predicted values, with one exception in which the measured value of a 4-db. rise, when the missile was completely out of the silo, was well within the acceptable tolerance band for the guidance system compartment.

Reaction time of Titan II—a fraction of the 15 min. required for surface-launch of Titan I—boosts sharply the missile's retaliatory potential. And its accuracy, equal to that of its predecessor Titan I, is shown by test program data to be better than that claimed by former President Eisenhower. There's no specific information available on the weapon's circular error probability (CEP), but industry speculation is that it might be as low as two-thirds of a mile. The general quantum improvement in ICBM accuracy is highlighted by comparison with the initial operating requirement—CEP of 5 mi.—established for the ballistic missile program in 1954.





effects of heat and vibrations on the missile as it emerged from the silo.

Fast-Reaction Strike Force

Each operational Titan II general area consists of two squadrons dispersed at 18 sites. The deployment is in 1 x 9 configurations—1 missile per complex and 9 complexes per squadron. This deployment, with hardness exceeding 300 psi. coupled with substantially decreased dispersion distances, achieves the same degree of invulnerability of Titan I. Effect is to economize in real estate and present to a potential enemy nine separate targets instead of three targets in each complex of Titan I.

Two companion squadrons are associated with a common SAC support base—two are based at Davis-Monthan AFB, Tucson, Ariz., two at McConnell AFB, Wichita, Kan., and two at Little Rock AFB, Little Rock, Ark. This squadron deployment, the result of a study to determine maximum cost effectiveness in terms of siting, ascertained that the use of one support base for three squadrons would not prove to be feasible.

Each missile site is approximately 600 ft. by 600 ft., has access roads, off-site utility and communications systems. Each facility consists of a launch silo, a launch control center, access portal and a blast lock, together with interconnecting cableways, all underground. The launch silo (AW, May 15, p. 119) is a reinforced concrete cylinder with a concentric steel and concrete inner cylinder. Inside depth of the silo is 146 ft. There are nine levels to accommodate the large quantity of associated equipment. Retractable access platforms at various levels extend down from the walls of the silo duct to surround the missile, which is shock-isolated in the launch duct. At the bottom of the launch duct is a W-type deflector which directs missile exhaust into two ducts bringing the efflux to the surface. Silo is lined with 3-ft.-thick acoustical modules and is closed with a 750-ton sliding door.

Control Center

Launch control center, a dome-shaped reinforced concrete structure approximately 52-ft. high with 42-ft. outside diameter, is a three-level shock-mounted facility. Upper level is used for eating and sleeping quarters for operating personnel, as well as a mechanical equipment room. Second level contains the control center and an electrical equipment room, and third level is used for equipment spares and miscellaneous storage. The control center is manned by a crew of four—two officers, and two NCO technicians. It also will accommodate a minimum operational crew concerned with daily care and surveillance, as may be needed. Connected to the launch control center is an air intake and emergency escape shaft. An enemy hit would create an overpressure which would automatically close a blast valve so that the subsurface facilities could operate for a specified period completely buttoned-up, using its own air supply.

Normal entry to the underground facility is through the access portal which leads down from the surface to the blast lock, through the lock and the cableways and from there either to the silo or to the control center. A reinforced concrete structure, the blast lock has heavy steel doors to seal off the control center from the silo and the access portal, to preclude any blast pressures caused by surface explosions or accidental explosions within the silo from reaching personnel in the control center.

A circular, stabilized, turn-around area on the surface above the silo accommodates a missile crane hardstand adjacent to the closure door, theodolite stand, and propellant terminal system oxidizer and fuel hardstands.

Missile Propellant

The missile's hypergolic propellant, consisting of a half-and-half mixture of unsymmetrical dimethyl hydrazine and hydrazine, plus nitrogen textroxide, is stored aboard the missile. Present limitation on the length of time the missile may be left in the silo in operational condition is not dependent on fuel storability.

Launch activation of the missile is accomplished by hard-wire electronic circuitry. Communication between the launch control center and any other point in the complex is by radio, found

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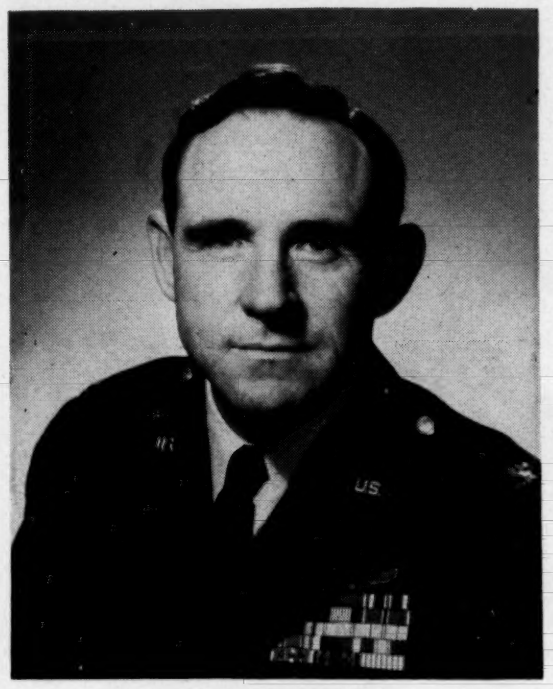


COL. J. L. McCOY, BSD, DEPUTY-TITAN SYSTEM PROJECT

to be less expensive and more adaptable to in-silo maintenance operations.

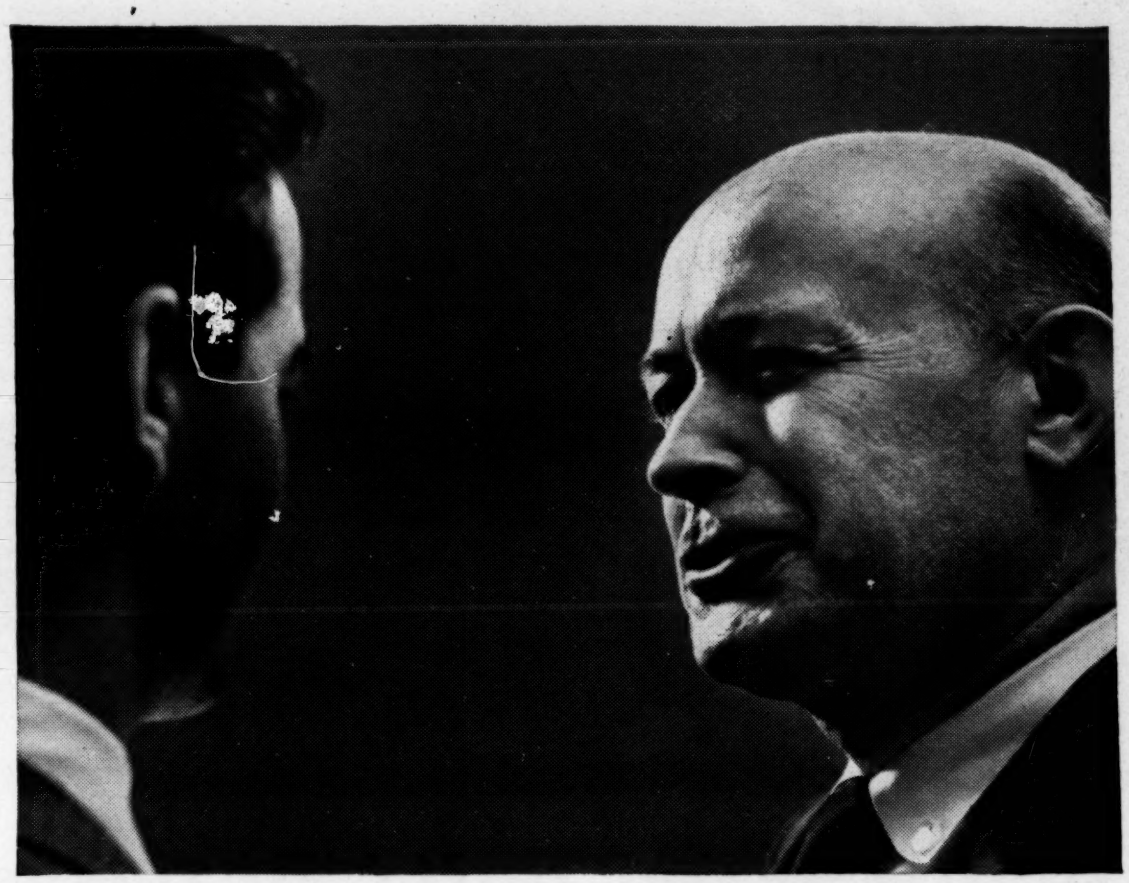
Titan II uses an unjammable inertial guidance system compared with Titan I's radio guidance system.

Initial operational sites for Titan I ICBM at Lowry AFB are scheduled to be turned over to SAC by the end of this year. Both first and second squadrons for Titan I will be located on Lowry's bombing range. Third squadron will be located in the area of Ellsworth AFB, near Rapid City, S. D., fourth will be near Beale AFB, Marysville, Calif., fifth squadron will be located near Larson AFB, Moses Lake, Wash., and sixth squadron will be near Mountain Home AFB, near Boise, Idaho. Each squadron will include three complexes in which three missiles are deployed (3 x 3 configuration).

The underground complex is self-sufficient when buttoned-up to operational hardness, which exceeds 100 psi.

Two antennas are available for each complex of three missiles, the second antenna being a backup unit, since only one is necessary for the launch operation. This arrangement was a tradeoff instead of providing each missile with its individual antenna, and thus contributes to cost effectiveness for the complex configuration. The antenna is raised from its silo and exposed only during the launch operation.

Key units in the Titan I complex include the missile silo, 160 ft. deep by 44 ft. dia.; a propellant terminal 35 ft. deep by 40 ft. dia.; equipment terminal 68 ft. deep by 43 ft. dia.; domed powerhouse 60 ft. deep by 127 ft. dia.; and entry portal, 72 ft. deep and 38 ft. dia.; domed control center, 40 ft. deep by 100 ft. dia.; and two antenna silos, 67 ft. deep by 38 ft. dia. Steel tunnels connect these underground installations, with blast locks at strategic locations.



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SANTA ANNA'S LACK OF RECONNAISSANCE..... MIDWIFE TO THE BIRTH OF TEXAS

Sam Houston said that knowing what the other fellow was doing placed him ahead in the game of war. Santa Anna frequently ignored reconnaissance.

These contrasting philosophies set the stage for a most remarkable battle. On a warm April afternoon, 1836, Santa Anna was enjoying a siesta. His aides sipped champagne nearby. Santa Anna's entire Mexican army felt secure as it nestled against the San Jacinto River.

Presumably, Santa Anna would have been more apprehensive if he had known that a courier, Captain Miguel Bachiller, had been captured by Deaf Smith, one of General Houston's highly effective "eyes." Also captured was correspondence which mentioned that Santa Anna was camped with only a 1,000 man vanguard. Sam Houston's 800 man army paused as Deaf Smith reconnoitered, returning with incredible news . . . not one Mexican scouted between the two forces. The Texans attacked . . . frontally over flatlands in the middle of the afternoon . . . and the result was surprise and victory.

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ATLAS 95D AT COMPLEX 576B

Atlas ICBM Geared to Total Deployment

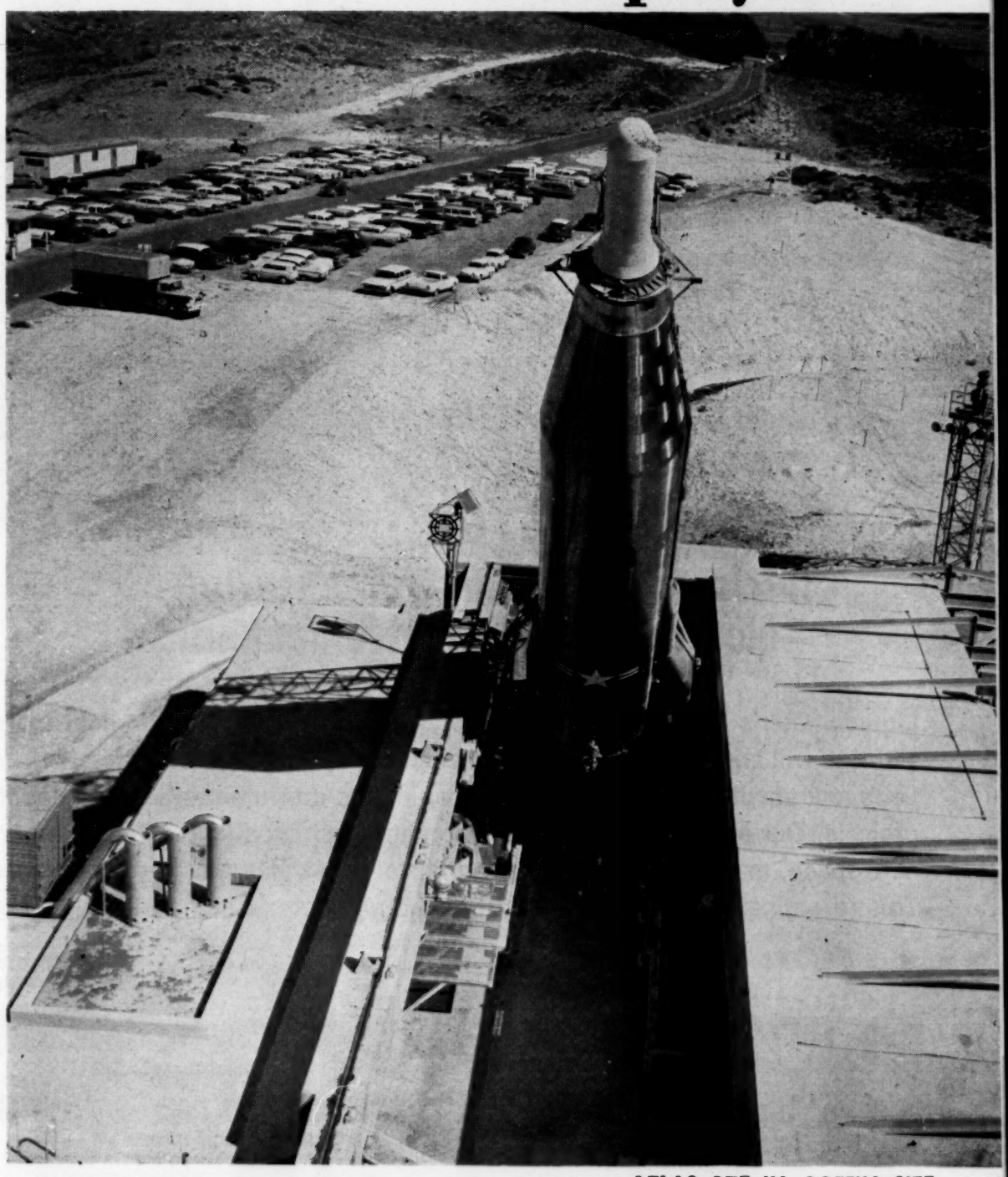
Inglewood, Calif.—Air Force's pioneer intercontinental ballistic weapon system, the Convair Atlas, is scheduled for total deployment before the end of 1962. Configured in three versions—Atlas F, E, and D—all Atlas D squadrons already are operational with Strategic Air Command.

In the push to get Atlas D deployed, a systems test facility for this version of the missile necessarily had to be bypassed, but a special updating project—Golden Ram—has provided new reliability inputs for Atlas D and also has provided valuable data for the Atlas E and F research and development programs.

Training complexes for Atlas E were turned over to SAC in June. Training complexes for Atlas F, which was first fired in flight test on Aug. 8, will be delivered to SAC at the beginning of 1962.

Test Results

Atlas flight test results have exceeded design performance goals. More than 100 of the Atlas missiles have been fired in research and development programs and as boosters for space program payloads. Support of the space effort looms large and current requirements for Atlas space boosters exceed the requirements at the operational sites (which already have been supplied), a sign that the Atlas program is far from ended. Indications are that peak production rate for Atlas will not be reached for six months and peak use probably will not occur for another year, since the increasing demands of the scientific space effort keep disap-



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pearing into the future. In addition to these experiments, some Atlas boosters are projected for Atomic Energy Commission experiments, bioastronautic experiments, and the SAC-conducted operational readiness training program is scheduled to assist with Atlas missiles in the Nike Zeus target program.

Atlas Prominence

Atlas also has been prominent in development tests of Minuteman ICBM components, particularly its re-entry vehicles.

The Atlas F firing on Aug. 8 was the third time the Minuteman re-entry vehicle was carried by an Atlas and dropped into the splash net at Ascension Island.

Atlas program also is contributing to development of sophisticated penetration aids for the over-all ballistic missile program.

A total of six Atlas F squadrons are scheduled to be turned over to SAC before the end of 1962. These squadrons each include 12 unitary silos, will be located at Schilling AFB, Kan.; Lincoln AFB, Neb.; Altus AFB, Okla.; Dyess AFB, Tex.; Walker AFB, N. M.; and Plattsburgh AFB, N. Y. Three unitary silos for Atlas F also have been constructed at Vandenberg AFB. One is a prototype operational silo test facility, while the other two unitary silos will be utilized for personnel training purposes.

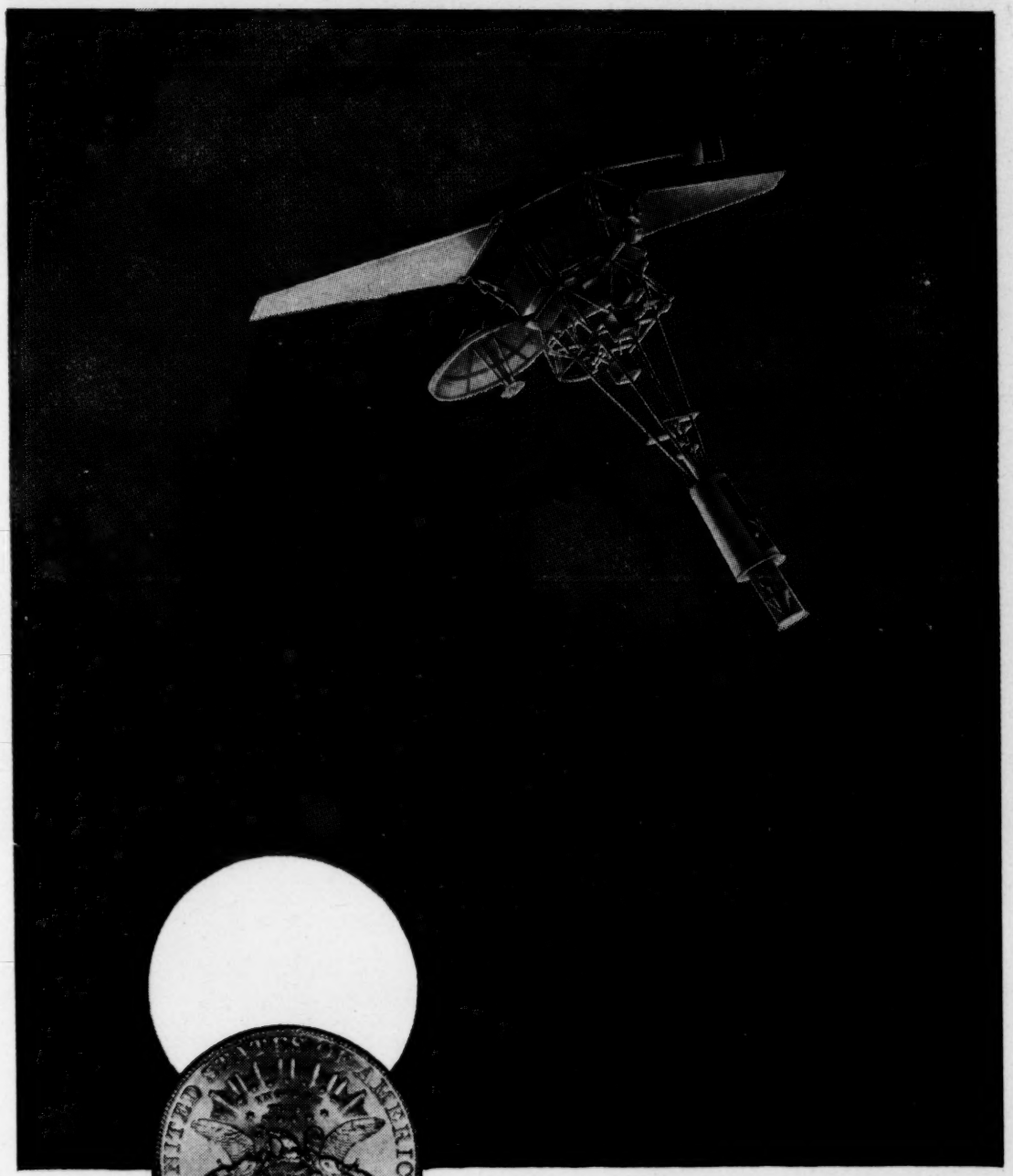
Deployment scheme is storage in the silo and raising the missile to the surface for firing. Silo has various equipment levels along its depth extending to the propellant loading system vessels on the bottom of the silo. The launch control center, hardened to a greater extent than the silo, is connected to the silo by a personnel tunnel, also reached by a descending stair from the surface.

Reaction Capability

Reaction capability is considerably improved over that of other Atlas models, possibly half the time formerly required.

Silo deployment for the F is completely self-contained, with powerhouse, hardened communication links, launch control equipment, air conditioning, propellant supplies, and readiness assurance testing capability. RP-1 fuel is stored aboard the missile and most of the liquid oxygen loading also is performed in the silo, with topping off, when the missile is raised to the surface, to replenish boil-off. Even after this operation, the missile may be taken down into the silo for a reasonable hold.

Both Atlas F and E models use a



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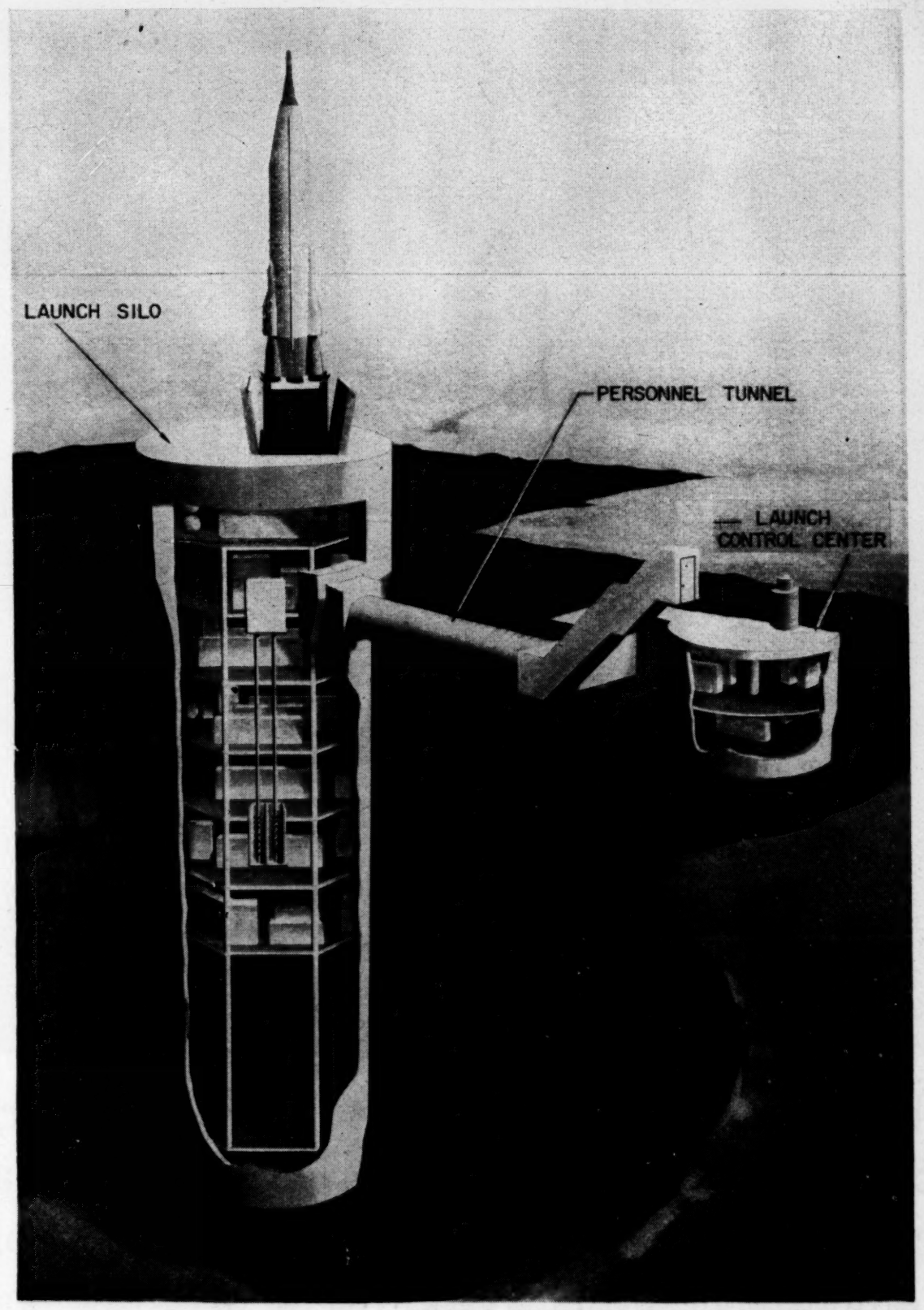
hypergolic start, while the Atlas D uses an ignition start with a hold-down provision to ensure that ignition has occurred properly. Because of the hypergolic start in F and E, baffled injectors are being incorporated which will eliminate the destructive possibilities of combustion instability (rough combustion) which, in previous test firings, has resulted in the loss of three missiles.

Checkout equipment for the Atlas F and Atlas E is simplified and mobile. Designated mobile automatic programed checkout equipment (MAPCE), the system uses a series of card decks for checking all major components, subsystems, and the launch system.

Use is mainly for assurance prior to launch to be certain of continued readiness of all systems and to afford maintenance and replacement information for the SAC crews when they receive the Atlas F.

Subsystem simplification of the Atlas F also is applicable to the Atlas E—booster engines are interchangeable, including the barrel, injection system, lines, pumps, etc. Guidance and reentry vehicles also are interchangeable between Atlas F and E, which can use the General Electric Mark 3 (also used on Atlas D) and the Avco Mark 4, the latter being considered standard for both the F and the E. Using the Mark IV, the tradeoff becomes one of range. However, even with this warhead the range established as the design and operational requirement— 5,500 naut. mi.—has been exceeded.



ATLAS F UNITARY SILO AND LAUNCH CENTER

Range Accuracy

With the Mark 3 re-entry vehicle, range of 7,850 naut. mi. (more than 9,000 stat. mi.) has been attained with "amazing" accuracy, since the inertial guidance system was not expected to approach the accuracy of the radio guidance system of the Atlas D.

Models F, E and D all are equipped with autopilots to provide initial stability before advent of the guidance system and to place the missile in its proper initial trajectory, first rolling it to the correct position, then pitching it to correct the exit angle, when the guidance takes over.

Category II program—system development test and evaluation—is scheduled to start approximately the first of next year for Atlas F. Updating of the Atlas F will depend upon the results of these Category II tests, but indications are that updating will be substantially less than for the Atlas D, because of the availability of the OSTF facility for the Atlas F.

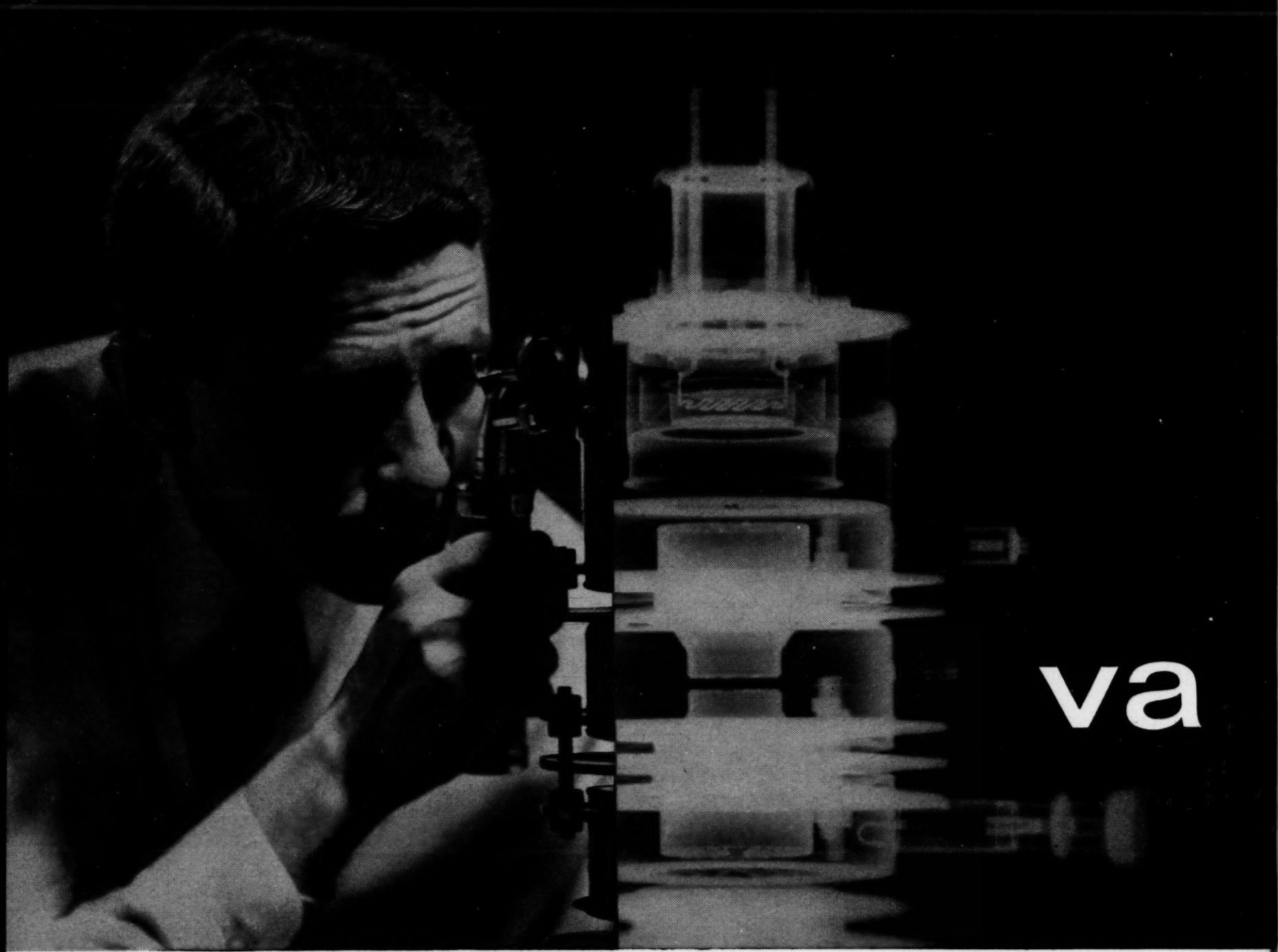
Only basic difference between models F and E is the reaction time and survivability stemming from hardness. Model E system is in the semi-hard category. Although it has a lower survivability potential than the model F from the standpoint of a near-miss, deployment of the model E involves a greater dispersion distance. The model E, in turn, is substantially harder than the model D, which was rushed from the research and development phase to operational status. The model E is stored in a horizontal position in a coffin-type emplacement below ground, but with its door flush with the surface.

After this protective blast door is opened, the Atlas E is raised to a vertical position and both fuel and liquid-oxygen are loaded and all subsystems are checked automatically end-to-end to ensure readiness. The erection process and propellant loading procedure mainly accounts for the reaction time which, nevertheless, is relatively fast and well within warning time available from BMEWS and other warning devices. Launch control center for E is harder than its below-ground coffin emplacement.

Atlas E squadrons will be deployed at Fairchild AFB, Wash.; Forbes AFB, Kan.; and Warren AFB, S. D., location III. Each will have nine pads.

Category II program for the Atlas E started in May and, like that for the model F, its results will determine the extent of updating required—now indicated to be relatively little. Operational deployment program for the E virtually is in accordance with the original schedule.

Squadrons for Atlas D, first operational Atlas model, are deployed at Offut AFB, Neb., in soft, above-ground shelters, for nine pad locations; at Warren AFB, Wash., location I, with six soft pads; and at Warren II, with nine



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Some typical Sperry programs benefiting from Value Analysis: (left to right) SP-3 Automatic Pilot for light aircraft; Army's SERGEANT missile system; Navy's Mark 19 Gyro-Compass; USAF's APN-59 Airborne Radar System; Klystron tubes for long range radar systems (main illustration).

SPERRY

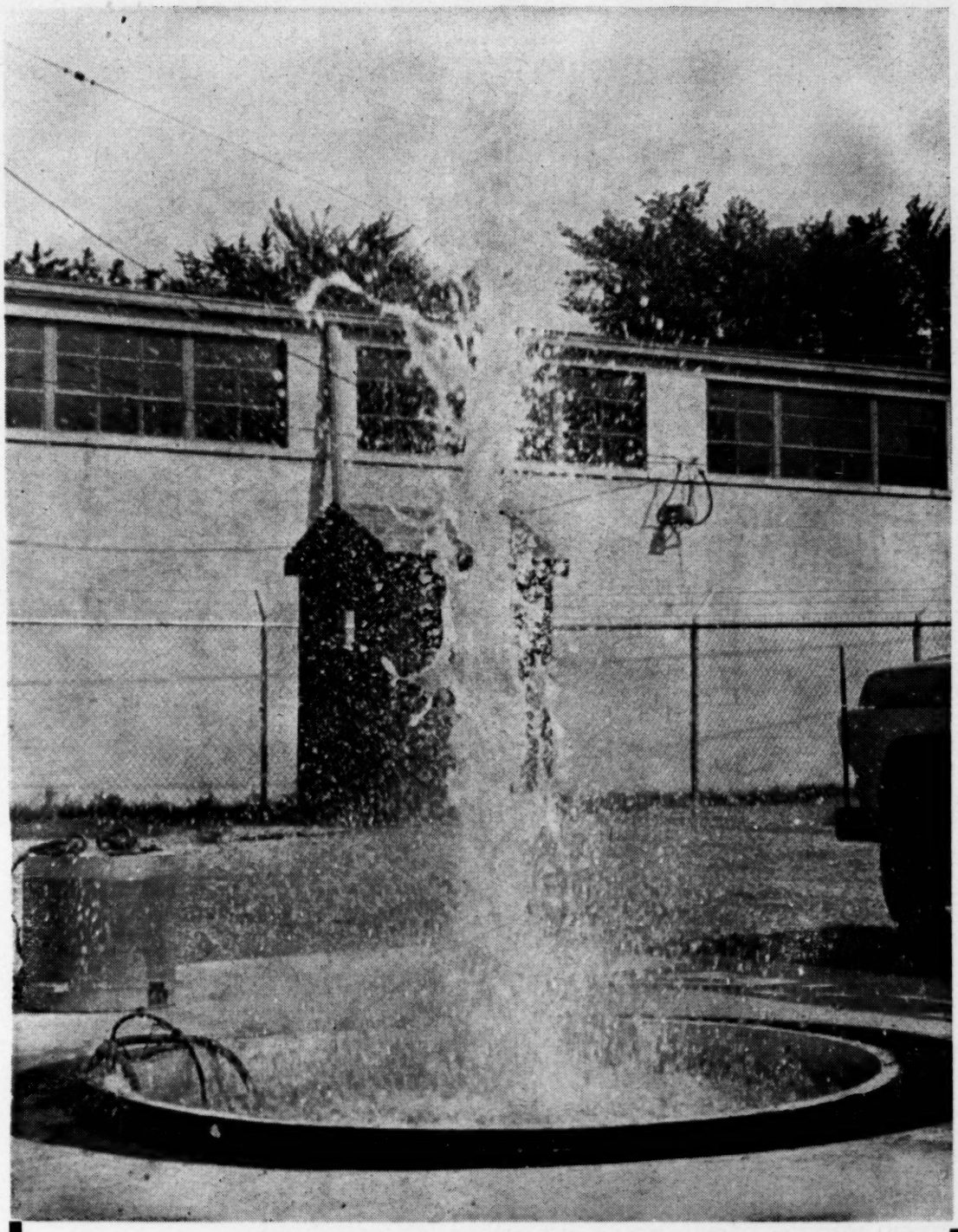
soft pads. Golden Ram, the updating program conducted from Vandenberg AFB over the Pacific Missile Range, to increase reliability of the Atlas operational system, has involved the following changes to the D model and, where applicable, to models E and F:

- **Propellant utilization system** has been removed. This was a major change which resulted because the installation was considered a maintenance difficulty particularly with respect to calibration, and the range available with the missile was so much more substantial than originally contemplated that elimination of the propellant utilization system did not compromise missile performance. Model E, which now uses the model D's former propellant utilization system, a Convair-designed manometer type, will be able to be fitted with the model F system if considered necessary. The Atlas F will use the Acoustica propellant utilization system, primarily because of the missile's substantially increased re-entry vehicle weight.
- **Hydrogen and helium filter** systems have been installed to prevent contamination that had been found to contribute toward failures.
- **Redundant circuitry** and equipment have been removed which, instead of providing additional assurance, contributed to increased complexity and lowered reliability.
- **Components with marginal** and erratic performance, such as fuel probes in the tanks, have been replaced.
- **Test procedures and sequences** have been corrected to insure that all subsystems which must be checked and validated prior to flight are accomplished in the proper order.
- **Redundant tests** eliminated.
- **New procedures** and instructions have been created relating to personnel and equipment safety, such as backout instructions which permit reversing the order of the checks to eliminate conditions which could cause loss of personnel and the missile. Another procedure instituted concerns interlocks which prevent inadvertent operation of equipment while maintenance personnel are exposed to danger.
- **Missile launchers** have been standardized to make logistic support and operation simpler and less costly.

"Cube" acquisition was the last flight experiment (Aug. 22) of the Golden Ram program. Performed many times at the Atlantic Missile Range, the technique was performed at Vandenberg AFB with SAC crews to demonstrate ability to "capture" the missile in flight with radio guidance delayed lock-on.

Atlas missiles will be fired from Vandenberg AFB's 576A pads—launchers of the gantry type are being converted for Nike Zeus support.

Atlas system program director is BSD's Col. J. L. Zoeckler.



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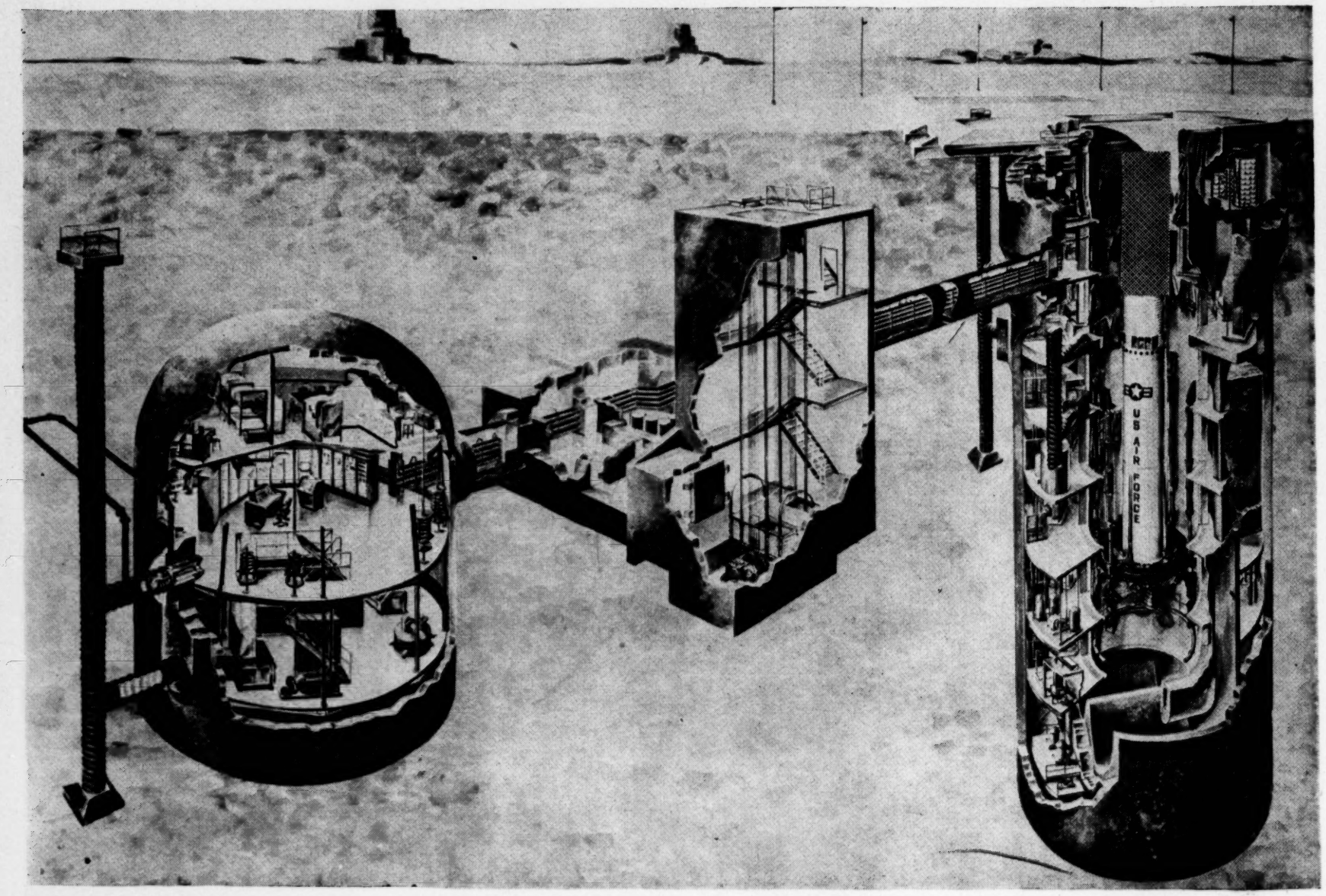

TITAN II UNDERGROUND launch center (left) joins access portal (center) through blast lock and cableways. Blast lock seals control center from both surface and missile silo (right). Silo has several levels for large complement equipment.

AF Group Prepares, Equips ICBM Sites

Torrance, Calif.—Task of preparing and equipping an ICBM site from design initiation to turnover of operational control to Strategic Air Command is the responsibility of BSD's Site Activation organization. Between these first and last steps is the gigantic job of managing and supervising site construction and the installation and checkout (I&C) of the maze of equipment associated with each missile site.

Magnitude of the supervision task is indicated in the geographical dispersion of a Minuteman ICBM Wing of three squadrons at Malmstrom AFB—approximately 190 mi. east-west and 110 mi. north-south. Titan II base of two squadrons spreads across 100 by 50 mi., and an Atlas F squadron dispersion area is 50 by 55 mi.

Site Activation Task Forces (SATAFs) are staffed to the Deputy for Site Activation and located at each Air Force base supporting the ballistic missile sites. Responsibility falls on the SATAF commander to activate his site successfully—its construction, I&C, and handover to SAC in an operational and supportable posture.

There are 18 SATAF commanders—senior colonels selected by Hq., USAF—to blanket Minuteman, Titan, and Atlas sites up to the time SAC takes over. No SATAF commanders have been designated yet for Minuteman sites at Minot AFB, N. D., and Whiteman AFB, Mo. Generally, however, intention is to have SATAFs at each new site as it becomes designated by Department of Defense. A single SATAF commander can manage a group of sites which incorporate more than one configuration of missile, such as out of Ellsworth AFB, which will support Minuteman and Titan I sites.

Reports

There is a close, but informal, tie-in between SATAFs. Thus, the SATAF commanders of particular missile-configuration sites, such as Titan I, generally are in daily telephone communication with each other, to relay problems encountered and how solution is progressing.

Some SATAFs issue a weekly report, on a voluntary basis, for distribution to other SATAF commanders of a like configuration.

There are periodic conferences between all the SATAFs to discuss work areas of mutual interest, not necessarily related to the particular weapon system at the site for which each is responsible.

Although not formally required, SATAFs also submit a monthly letter to Commander, BSD, relating to information they feel he would like to have. In his weekly replies, the BSD Commander extracts useable information from these monthly letters, forwards it to other SATAF commanders.

In addition, SATAFs submit formal reports to the BSD Commander on a monthly basis.

BSD staff visits also check SATAFs periodically, not less than once every six months.

Every SATAF commander receives a copy of each BSD Hq. Dynamo alert (see page 123) and associated situation report, until the alert is killed.

SATAFs were constituted July 11, 1960, to provide greater unity of Air Force direction for the site efforts of the (then) Air Materiel Command, Bal-

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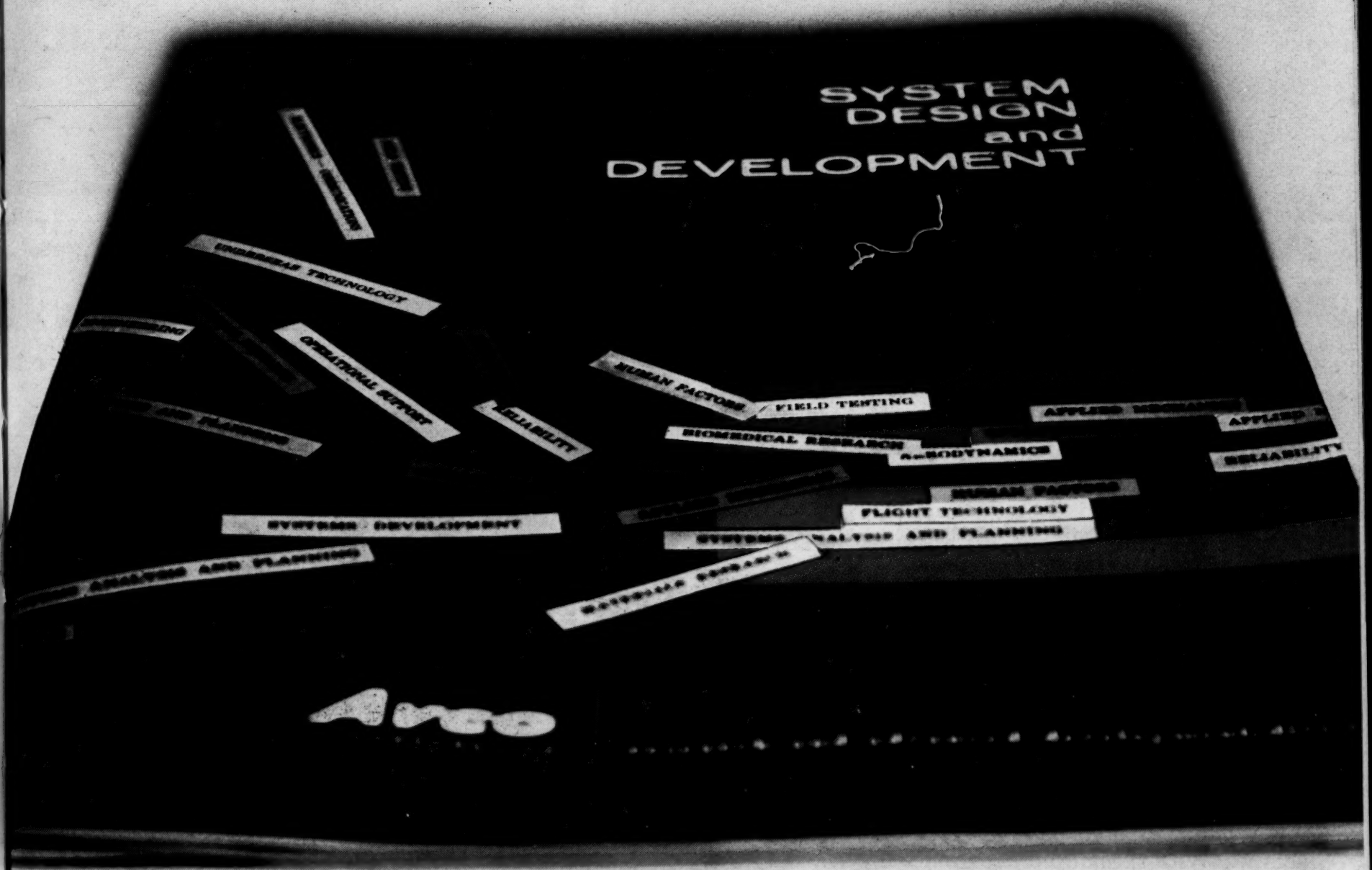

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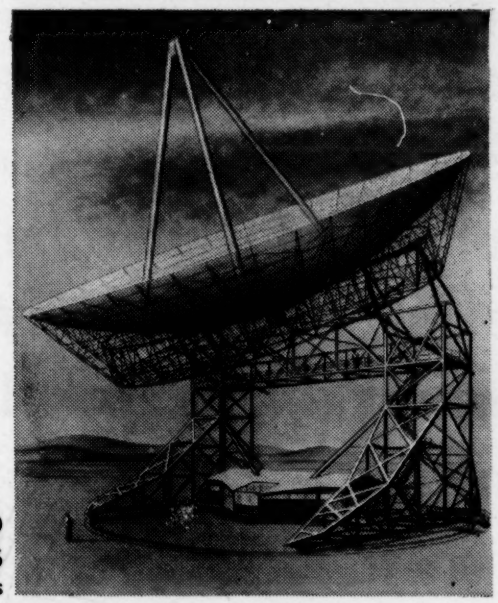

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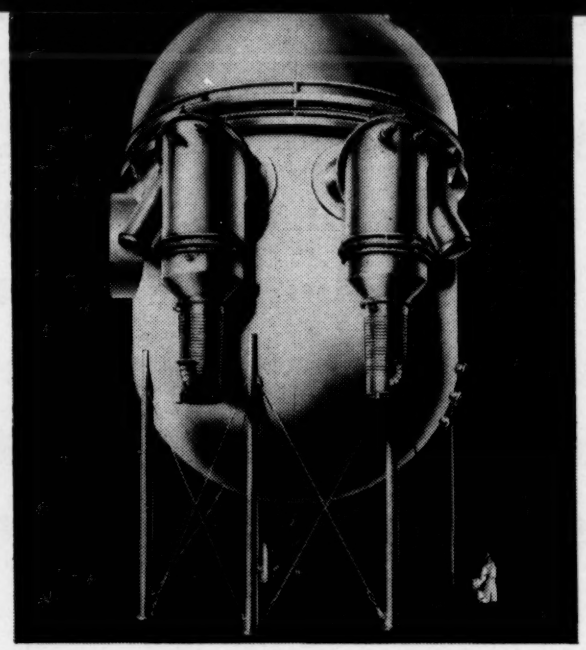
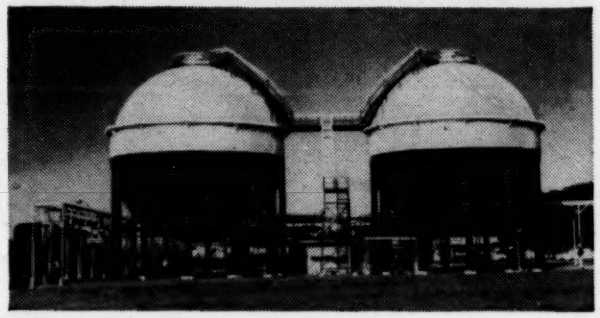
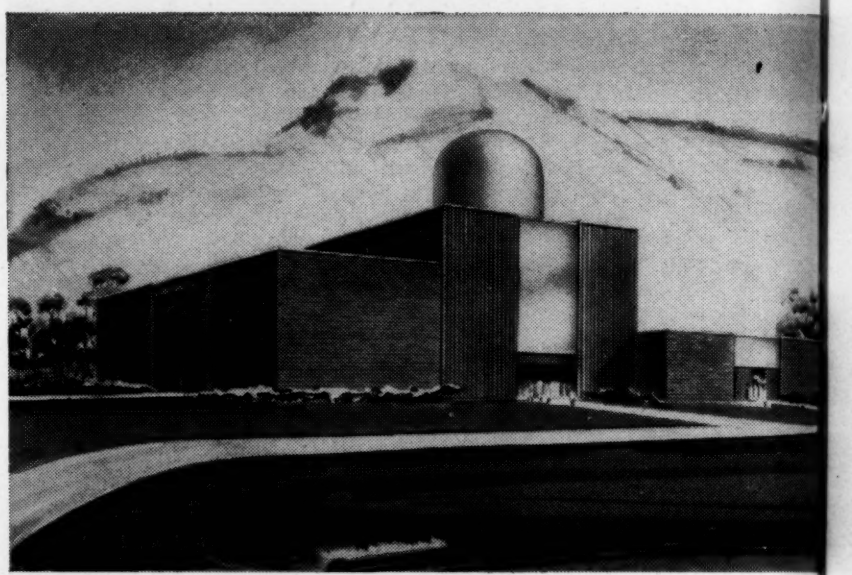


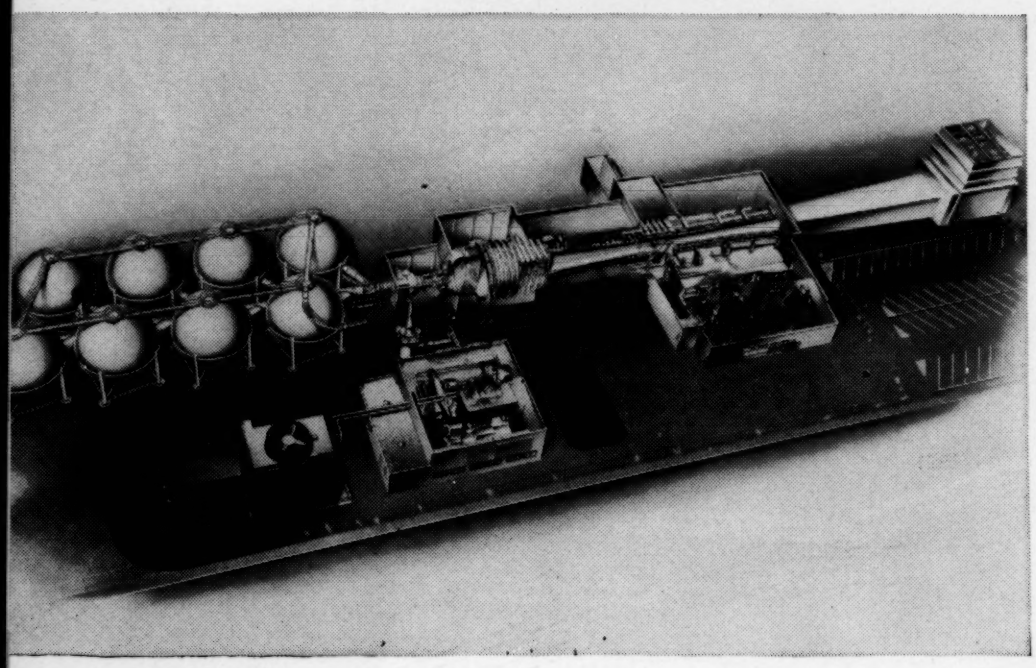
SPACE SIMULATION
General Electric Company
Valley Forge, Pa.

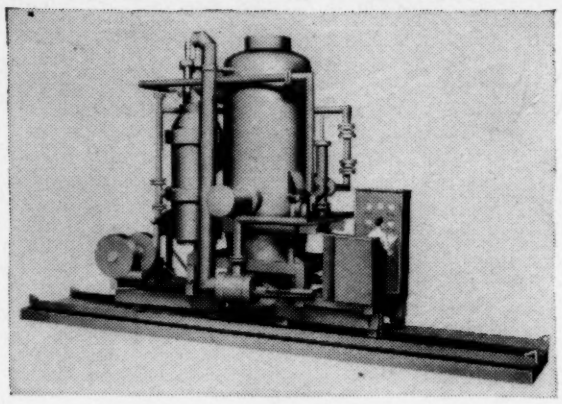


CRYOGENIC STORAGE
Linde Company
Huntsville, Ala.



WIND TUNNEL
North American Aviation, Inc.
El Segundo, Calif.





TEST FACILITIES
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HEATER
Johns Hopkins (APL)
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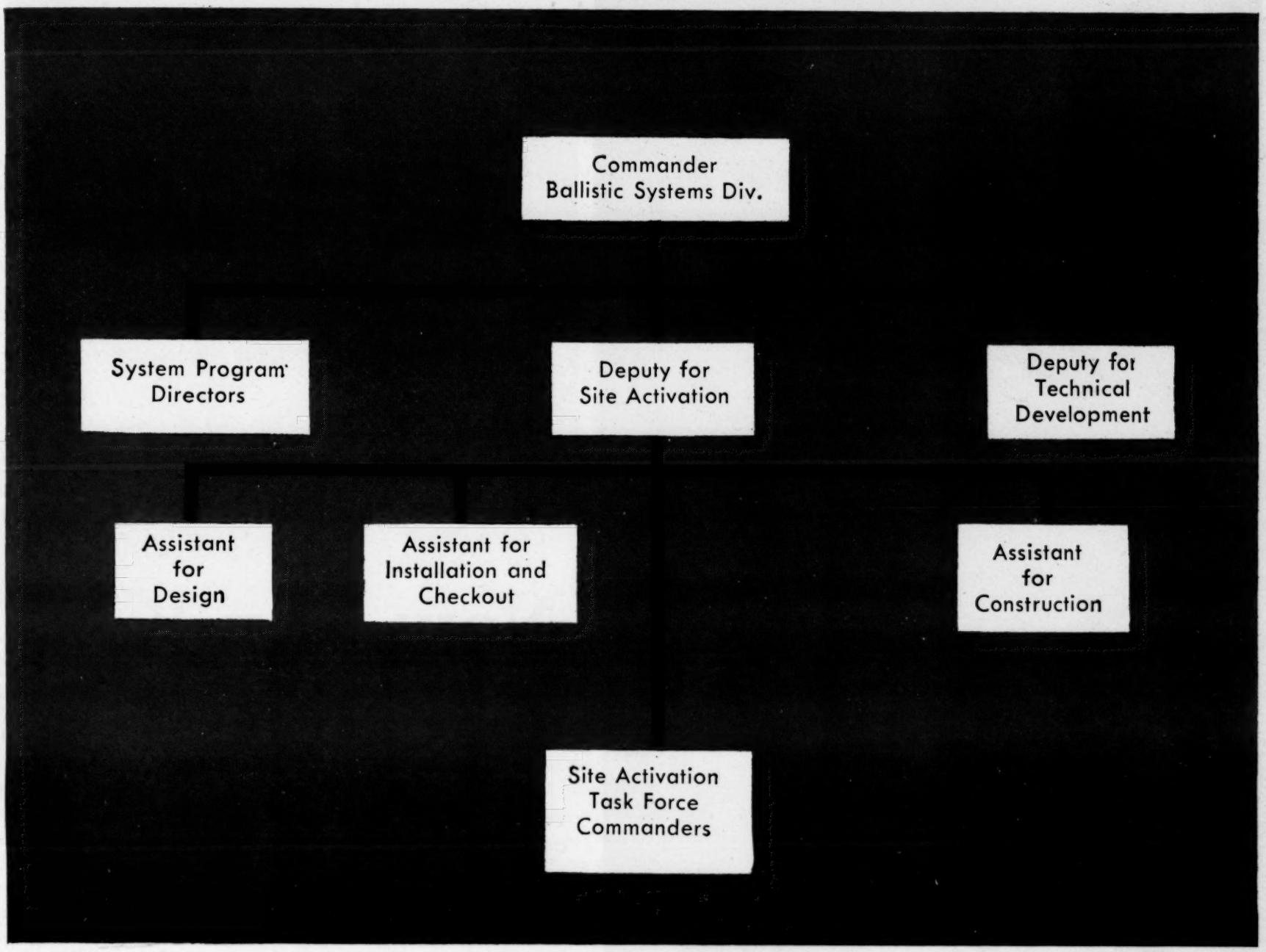

DEPUTY FOR SITE ACTIVATION IS FOCAL POINT IN BSD

listic Missile Division, and the contractors. Along with this move to bring about more unified control, the area engineer offices under the various Corps of Engineers districts were realigned, April '61, into the Corps of Engineers Ballistic Missile Construction Office (CEBMCO), which was transferred to the BSD staff under the Deputy for Site Activation, who reports to Commander, BSD.

CEBMCO, responsible for the construction phase of the site activation program, is staffed by Army Corps of Engineers personnel under a better "physical activity" with the Air Force than existed before the creation of the CEBMCO office directly under BSD. The deputy for construction at a particular missile site is under the operational control of the SATAF commander, but his contractual direction comes from CEBMCO.

After a joint review of plans and specifications with the architectural and engineering contractor and the Air Force design office, CEBMCO puts together a "contract package" so that it may be let for building of the launchers, launch control center and affiliated support facilities.

This work is advertised, bids are reviewed and awards are made. CEBMCO administers the contract until work is completed.

For each site, there is a field organization or area office functioning to supervise the construction and activities of the contractor and administer the contract in the field. The area engineer has considerable contractual authority delegated to him.

MAJ. GEN. A. C. WELLING, U.S.A.
DEPUTY, SITE ACTIVATION

When construction is completed, the facilities move into the installation and checkout phase. While CEBMCO's activities—including installation of such items as generators, missile brackets, propellant loading systems, blast valves, etc.—normally terminates at the end of the construction phase there is a continuing interface liaison during construction in which CEBMCO participates with the SATAF which "clears" the interface so that CEBMCO can move ahead with its work until it gets to the next interface resolution point.

This coordination is in accordance with an interface handbook.

Ramifications of the installation and checkout effort associated with a ballistic missile weapon system are typified by the procedure for the Atlas E, deployed in a semi-hard, below-ground coffin installation. I&C effort for Atlas E is now in its final stages at the operational sites. The procedures generally apply to Atlas F, deployed in a below-ground silo from which the missile is raised for launch, except for variations (principally launch platform and erect-

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Because of the added quality of flexibility, Min-K's unique insulating characteristics now can be used in virtually unlimited new applications. For full details on Flexible Min-K, Min-K and other J-M aviation insulations, write Johns-Manville, Box 14, New York 16, New York. In Canada: Port Credit, Ontario. Cable address: Johnmanvil.

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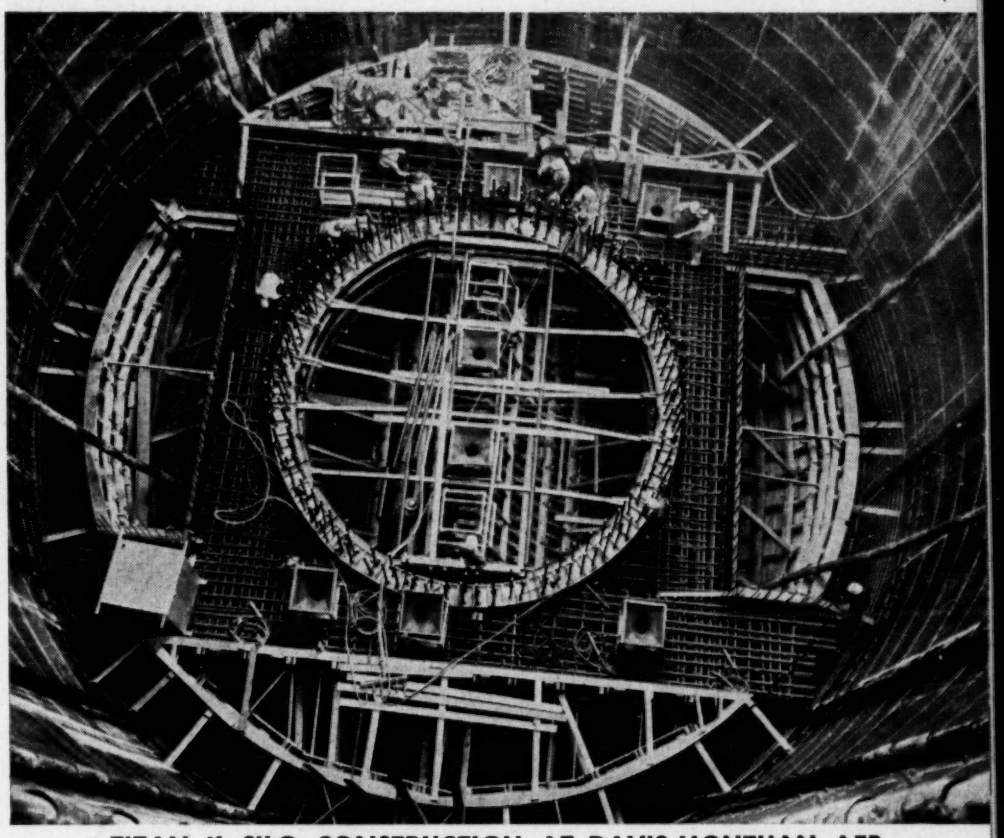


TITAN II SILO CONSTRUCTION AT DAVIS-MONTHAN AFB

ing mechanism] introduced by this vertical unitary concept as distinguished from the horizontal concept for the Atlas E.

For Atlas E, the site activation mission from the time of groundbreaking to turnover to Strategic Air Command encompasses about 20 months. Job of construction may take about 12 months, the actual I&C task may require approximately eight months. (Site activation for Atlas F would require a longer period of time.)

Installation and Checkout

The I&C effort is divided broadly into these four phases—installation of hardware, checkout [validation] of the various end items in the subsystems, integration of subsystems and systems, and technical acceptance demonstration.

Phase I consists of installing various units of ground environment equipment, such as launcher platform and associated boom, erection mechanism and motor control equipment, pressure control unit for Atlas structure, which automatically maintains the missile in its pressurized status, the launch control console, and logic and responder units. It also involves the hookup of connecting services—electrical, hydraulic and pneumatic. The installation is performed by subcontractors of General Dynamics/Astronautics, the prime contractor, under the supervision of the latter's engineers.

In Phase II, the various subsystems are checked by systems engineers of the prime contractor (General Dynamics/Astronautics) and involves the use of a mobile, automatic, programing and checkout equipment [MAPCHE] trailer —an analyzer on wheels—which is connected electrically to junction boxes in the facility. Punched card decks are fed into this trailer system for the weapon system subsystem checkout. Numerous decks are employed and the size of the deck depends upon the specific subsystem. There is a tape readout which can indicate a "no-go" condition, in effect a rejection of the particular card.

There are never less than three men involved in the procedure—two in the trailer, one at the general location of the subsystem, and communication is with headset intercoms.

Phase III is a checkout of the complete weapon system, less the warhead, with the missile installed in the coffin. Here again, extensive use is made of the MAPCHE trailer. Phase III is performed by the prime contractor, using its own engineering procedures because during this phase it is not obliged to follow Air Force technical data, except at the conclusion of the phase, when the contractor rechecks the weapon system, using Air Force technical orders, including manuals and inspection and trouble-shooting procedures, which will be used by SAC crews in the operational mode.

Phase III check involves propellant loading and use of pressurizing gases and system operation progresses through engine "ignition" at the end of a complete countdown. To simulate this engine ignition, a small fuze is used and if it is blown the system is considered validated through the commit sequence.

Installed equipment in the weapon system provides continuous monitoring of the guidance system to show if it is integrating or whether there is a failure.

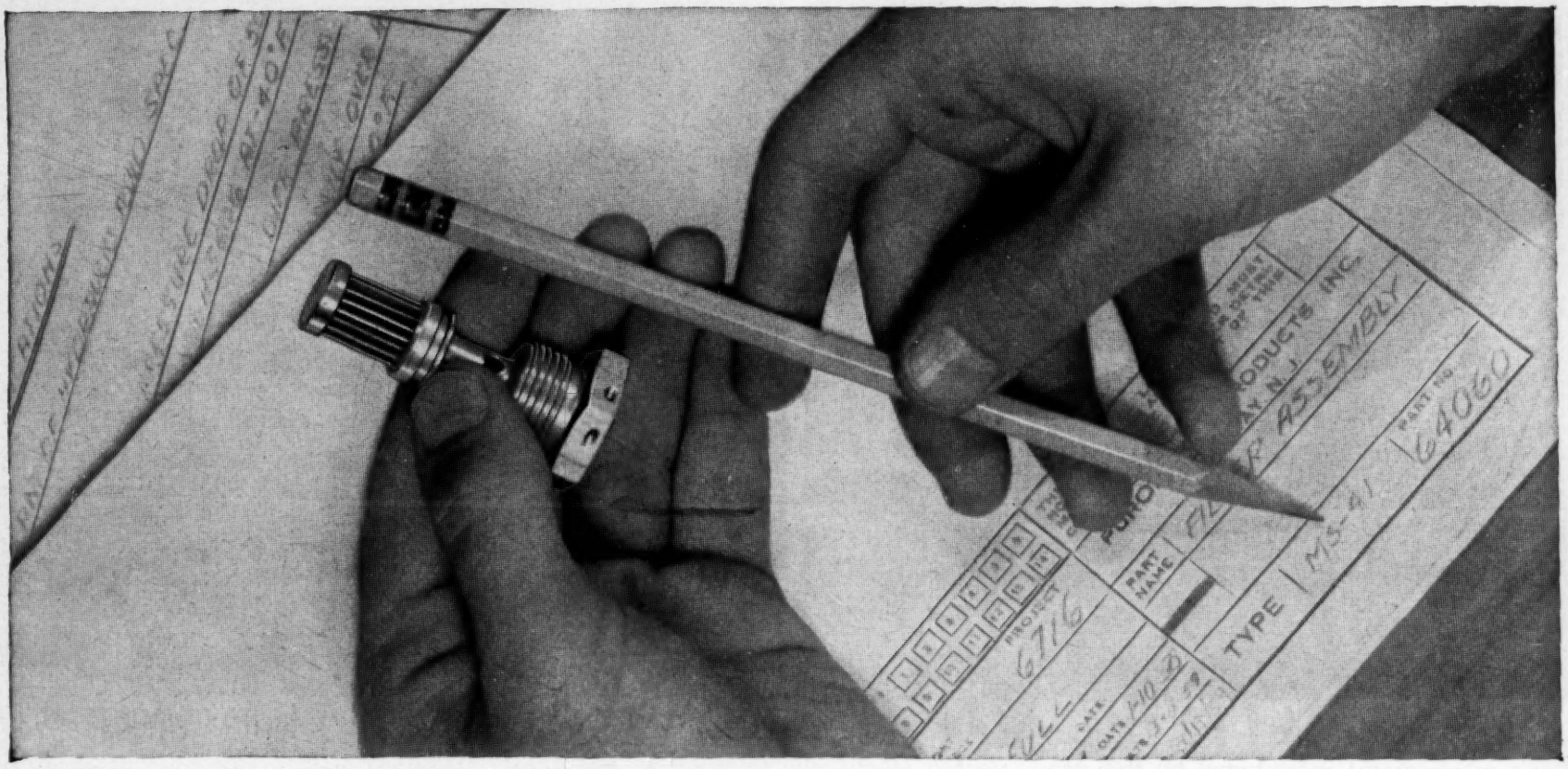
Phases I, II and III are performed without a real re-entry vehicle, but a device is used which simulates the installation of the nose cone to check out the electrical circuitry. The true re-entry vehicle is not installed until the very end of the I&C phase and this installation, checkout and qualitative control is conducted under the most stringent security measures, requiring special clearance for the limited number of contractor re-entry vehicle personnel employed in the I&C phase. Warhead is not installed in the re-entry vehicle until the facility is under SAC's complete control.

Phase IV

Phase IV, the technical acceptance demonstration by the contractor to the Air Force—SATAF and SAC—is to ensure that the weapon system will perform in its operational manner. The MAPCHE trailer also is used in this I&C phase and, as a universal piece of government-furnished-equipment, also is phased into operational use with SAC as required for periodic checkout and for trouble shooting. However, in its operational mode, the missile site is not dependent on the use of MAPCHE equipment.

During Phase IV the SAC crew operates the system under the supervision of the contractor, using Air Force technical orders, hence this is, in effect, a repetition of what the contractor performed under Phase III.

SAC's activity doesn't begin with Phase IV, since "Blue Suit" personnel—officers and non-commissioned officers—are on the site throughout the entire I&C phase and, in some cases, even earlier. These SAC personnel, which eventually will maintain and operate the ballistic missile squadron, are assigned to the SATAF under its ostensible control. Primary purpose is to have



Miniaturized cavity-type filter packs 4.2 square inches of filtering area into 1" x 9/16" element

Purolator develops thumb-nail size element to protect hydraulic control circuits on Army's Hawk Missile mobile launcher.

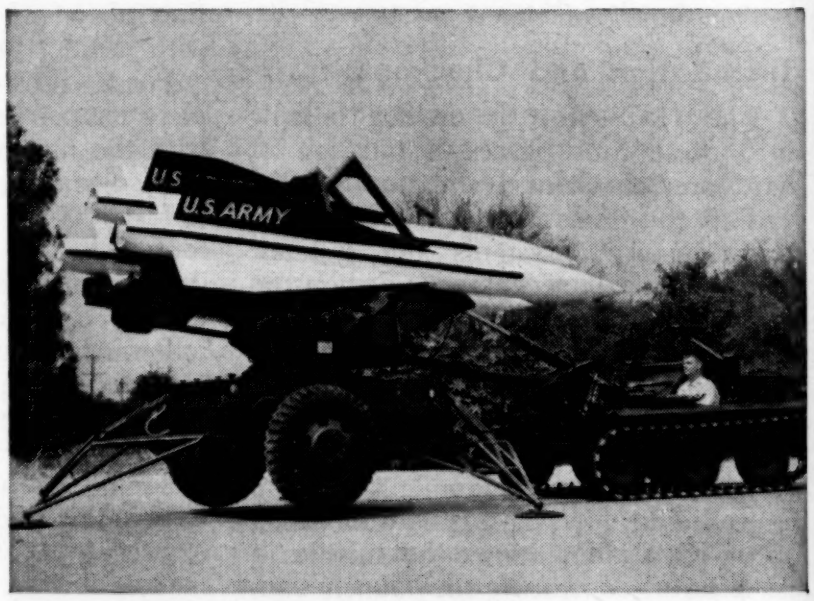
How small can you make an element that must filter 2 gpm hydraulic oil at 2500 psi at any temperature within a 315° range? Purolator's new miniature cavity-type hydraulic filter is the best answer to date. Here's why:

4.2 square inches of convoluted stainless steel wire cloth are packed into this miniature filter. This element, which weighs 0.25 ounces, filters two gallons per minute of hydraulic oil, at temperatures ranging from —40° to + 275° F. The element will withstand 2500 psi differential pressure without collapsing.

The element is made up of a total of ⅕-mile of stainless steel wire, woven into wire cloth and convoluted to extend filtration area. This element will remove 98% of all particles whose two smallest dimensions are larger than 10 microns, and 100% of all particles measuring 25 microns or more.

The picture at the top of the page shows you the complete filter assembly, ready for installation in the hydraulic control system. The overall length of the unit is 2 1/32"; maximum overall diameter is 1". Total weight is slightly over 1 ounce. Designed as a cavity-type unit, the filter is installed simply by screwing it into the hydraulic system so the filter element intercepts oil flow. The element can be removed, cleaned and replaced without special tools.

The picture at right shows the mobile launching platform for the Hawk Missile. The compactness and mobility of the



launcher, and the probability that it would be subjected to severe jolting, made it necessary to specify as small a filter as possible, and one that could be integrated with the rest of the system for maximum simplicity and durability.

The Purolator engineers who developed this new miniature cavity-type filter are available now to design a filter to meet your specifications. Simply contact Purolator Products, Inc., Department 3096, Rahway, New Jersey.

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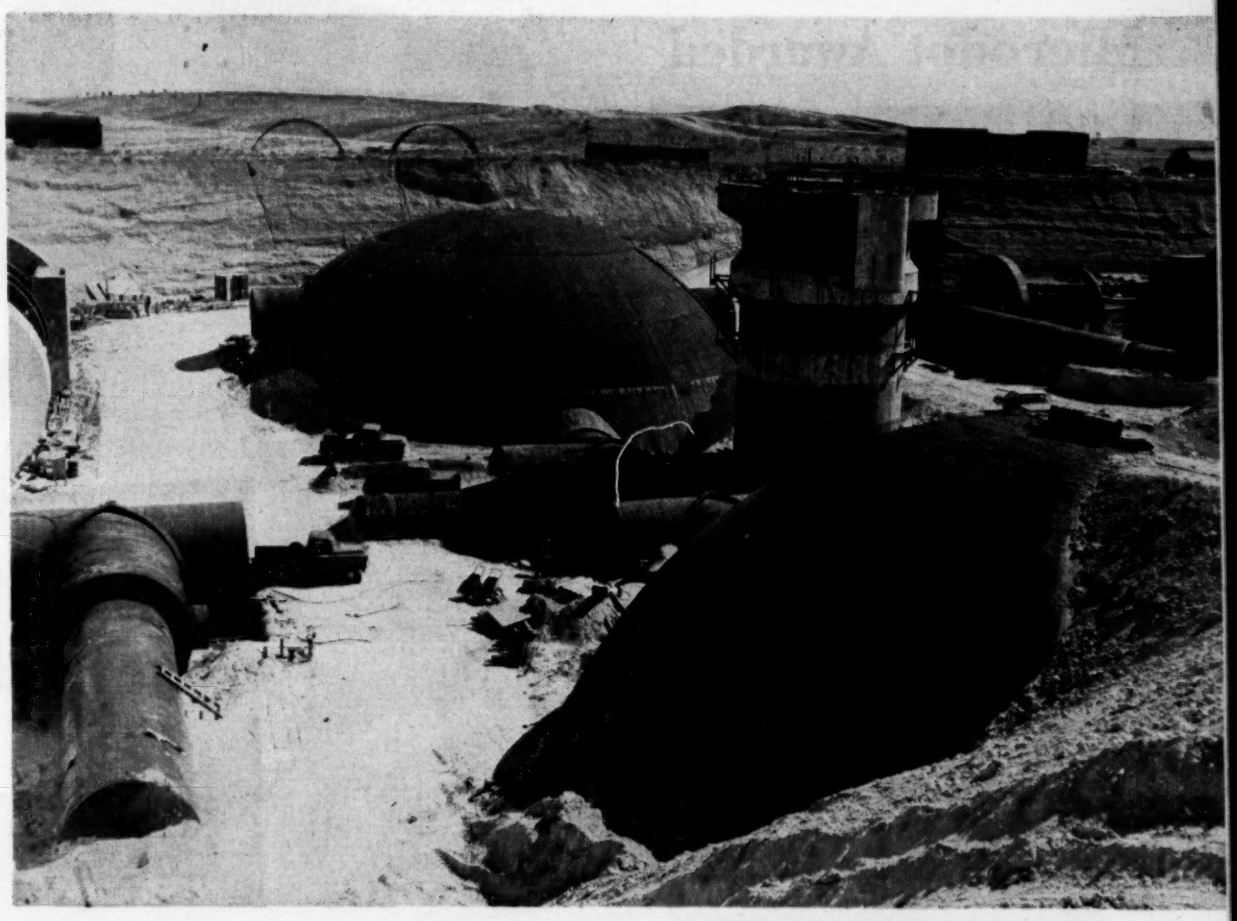
a SAC crew on the site for their general familiarization with the specific base at which they will operate. This is additional "education" to that received with the Air Training Command and at Vandenberg AFB, where Category III system operational test and evaluation is conducted.

Learning curve for I&C is improving progressively and, as a result of experience to date, improved planning procedures and management controls have been developed for more efficient accomplishment of the I&C job in the ballistic missile effort.

The I&C peak for the ballistic missile program probably will involve a contractor force of approximately 35,000 persons.

Construction contractor employment peaked at about 20,000, current contractor personnel totals about 18,000.



TITAN I COMPLEX BEFORE COVERING, LOWRY AFB

Construction Status

Minuteman site construction at Malmstrom AFB commenced Mar. 16, under contracts awarded Feb. 28. Construction completion of the first flights (each of the three squadrons comprises five flights of 10 silos and one launch control center) is scheduled for late this year, with the 15th flight construction likely to be completed late in 1962. Work has commenced on more than 145 of the total of 165 (150 silos and 15 launch control centers) construction sites. Overlot grading and open cut excavation has been done, shaft excavation is in progress in various stages on more than 75 sites, concrete has been poured on more than 65 sites, and mechanical and electrical work is progressing on more than a dozen sites.

Construction contracts for Minuteman facilities at Ellsworth AFB were awarded Aug. 1.

First flight is scheduled for completion in the fall of 1962 and the last in early 1963.

Contract awards or specific scheduling have not been finalized for construction at Minot AFB, N. D. and Whiteman AFB, Mo.

Titan II Effort

Titan II effort represents for the first time in the ballistic missile program a construction procedure divided into three phases to allow construction to start on major structural items while design for the remaining facilities is being completed.

All Titan II bases should have construction completed by February, 1963. Construction for Titan II facilities at Davis-Monthan AFB started on Dec. 9, 1960. This Phase I construction (excavation and major heavy concrete and steel) is scheduled to be completed on 10 silos now (Sept. 25).

Phase II construction (inner launch duct, electrical and mechanical equipment, and the 750-ton, 4-ft. x 41-ft. x 64-ft. silo door on tracks) is expected to be completed on the first units by the end of March, 1962, and thereafter at the rate of about one silo every two weeks.

Phase III is to be done within the same time frame as Phase II. Contracts will be let in mid-October and work is scheduled to be finished at about the same time as Phase II is completed. Phase III comprises completion of work in the launch duct proper, such as acoustical lining material and moveable work platforms.

18 Sites

Construction of all 18 sites at Davis-Monthan AFB is scheduled for completion by November, 1962.

McConnell AFB schedule follows Davis-Monthan by approximately two weeks, and Little Rock AFB's timetable trails Davis-Monthan by about four weeks.

For Titan II, 25 packages of equipment have been standardized—purchased for all sites by CEBMCO contracting officer as GFE for Phase II and III contractors instead of delegating this responsibility to the contractors. Packages include items such as hydraulic systems for platforms and doors, air-conditioning, standby Diesel generators, etc.

No joint occupancy now is planned and I&C work will start after construction is completed to minimize interference in each site. However, joint occupancy may be necessary if changes extend the construction period.

Titan I construction program is entering its final phases. Anticipation is that final Titan I squadron will be turned over to SATAF for I&C work in April, 1962. First of the six Titan I squadrons was turned over on schedule Aug. 4. This squadron is spread over Lowry AFB bombing range.

- **Second squadron**, also spread over Lowry bombing range, is scheduled to be turned over for I&C on Nov. 1.
- **Third squadron**, in the area of Ellsworth AFB, is scheduled for delivery to I&C on Dec. 15.
- **Fourth squadron**, near Beale AFB, has Feb. 1, 1962, for the I&C turnover date.
- **Fifth squadron**, near Larson AFB, is scheduled to be turned over on Apr. 11, 1962, for I&C.
- **Sixth squadron**, near Mountain Home AFB, is targeted for turnover to I&C on Apr. 1, 1962.

Meanwhile, where possible, I&C type of work is under way at the sites through joint occupancy with SATAF and associate contractors, depending upon the state of construction on each specific facility.

Notice to proceed with Atlas F squadron construction at Schilling AFB was issued Mar. 7, 1960. The final, twelfth silo launch facility was completed June 16, 1961.

Atlas F Silos

At Lincoln AFB, notice to proceed was issued Apr. 15, 1960, and six Atlas F silos have been delivered for I&C. All twelve installations should be completed by approximately Oct. 24, according to present schedule.

Notice to proceed at Altus AFB was issued May 4, 1960. First site was

Microdot Awarded Contract on Midas

LOS ANGELES, CALIF.—Contracts in excess of $225,000 have been awarded to Microdot Inc. by Philco Corporation's Western Development Laboratories for UHF narrow-band data link transmitters and subassemblies to be flown in the Midas missile alarm satellites.

The Midas project, under cognizance of the United States Air Force, is aimed at development of a national early warning capability through multiple satellite coverage of the earth's surface via infrared detectors. Philco, with responsibility for the instrumentation, is an associate contractor to the Air Force. Lockheed Missiles & Space Company, prime system contractor, is responsible for the total vehicle and ground elements of the system, integrating associate and subcontractor efforts.

Microdot model 2406A UHF Telemetry Transmitter, similar to units now in production for the Midas satellite program.

In May, 1960, a Midas satellite was launched into near perfect orbit 300 miles in space. The 5000-pound satellite, over 21 feet high, carried a 3600 pound instrumented package. Then in July of this year, Midas III was placed into an 1850 nautical mile orbit. Again a near perfect circular orbit was achieved. Continuation of test firings are anticipated with the program remaining a high priority national development.

For Midas, Microdot will supply their Model 2406A Telemetry Transmitter modified to include self-monitoring and telemetering of its own operation. The transmitter is miniaturized, pressurized, and includes its own solid state power supply. Reduction in size is gained through use of a unique automatically stabilized circuit, with the output frequency referenced directly to a quartz crystal. The transmitter weighs 12 pounds. Similar Microdot telemetry equipment has been a part of such projects as Pioneer V, Jupiter, Atlas, Pershing, Redstone, and Echo I.

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South Pasadena, California

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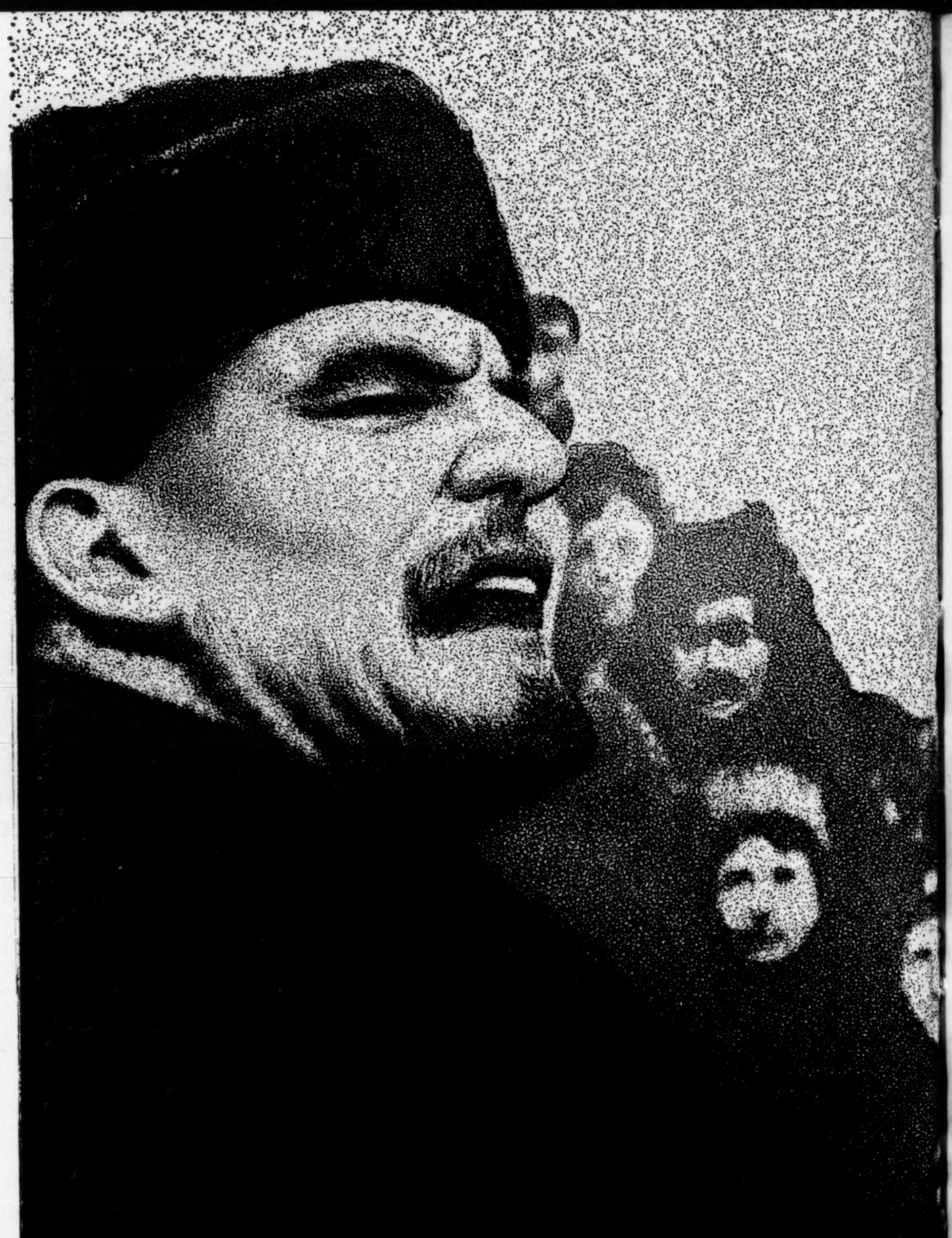

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Remember them . . . particularly when your contribution to defense—to the potential terror of space age war—chafes at *your* principles.

They'll help you know that what you do keeps fingers off buttons . . . that the real business of the defense business is survival.

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delivered to I&C on Aug. 1. The twelfth site is scheduled for completion Nov. 1, 1961.

At Dyess AFB, notice to proceed was issued May 27, 1960, first launcher was delivered to I&C on June 21, 1961. Twelfth was scheduled for turnover on Sept. 12.

Notice to proceed at Walker AFB was issued June 20, 1960. Plan is to deliver the first installation to I&C in mid-October, 1961, and the final silo facility at about Jan. 1, 1962.

Plattsburgh AFB notice to proceed for Atlas F was issued June 16, 1960; first facility is to be delivered in the middle of October, 1961, and the last is to be delivered immediately after the first of the year.

Atlas Programs

Construction programs on Atlas D and E are completed. Atlas D, housed in a soft shelter aboveground, will be deployed at nine pads at Offut AFB, six pads at Warren AFB area I, and nine pads at Warren II.

Atlas E has nine pads each at Fairchild AFB, Forbes AFB, and Warren AFB area III.

These installations are semi-hard, below-ground coffin-types, with deck flush with the ground.

There's more than just heavy construction involved in CEBMCO's efforts—there are control procedures involving refined checkout. Titan I facilities are typical of these care-areas for liquid-propellant facilities. For example, extreme cleanliness requirements demand that any propellant loading system contaminant 150 microns or larger be removed to avoid jeopardizing the operation of the missile. Piping valves are put through initial cleaning plant above ground to remove any hydrocarbons, then are flushed, passed through drying and examining facilities for black light check. Pipe or valve is flushed again in millipore test and filter is examined microscopically for 150 micron or larger particles, then sealed with polyethylene and moved to the construction site where, under rigid controls, the equipment is unsealed and installed.

Black Light Tests

During this phase, inspectors continue black light tests and are empowered to reject equipment, if it is found necessary.

After completion of the propellant loading system, there is an over-all checkout, which may require as much as two months, to proof-pressure the system, using blowdown filter pads at strategic points to trap evidence of any residual contamination.

Deputy for Site Activation under BSD is Army's Maj. Gen. A. C. Welling.

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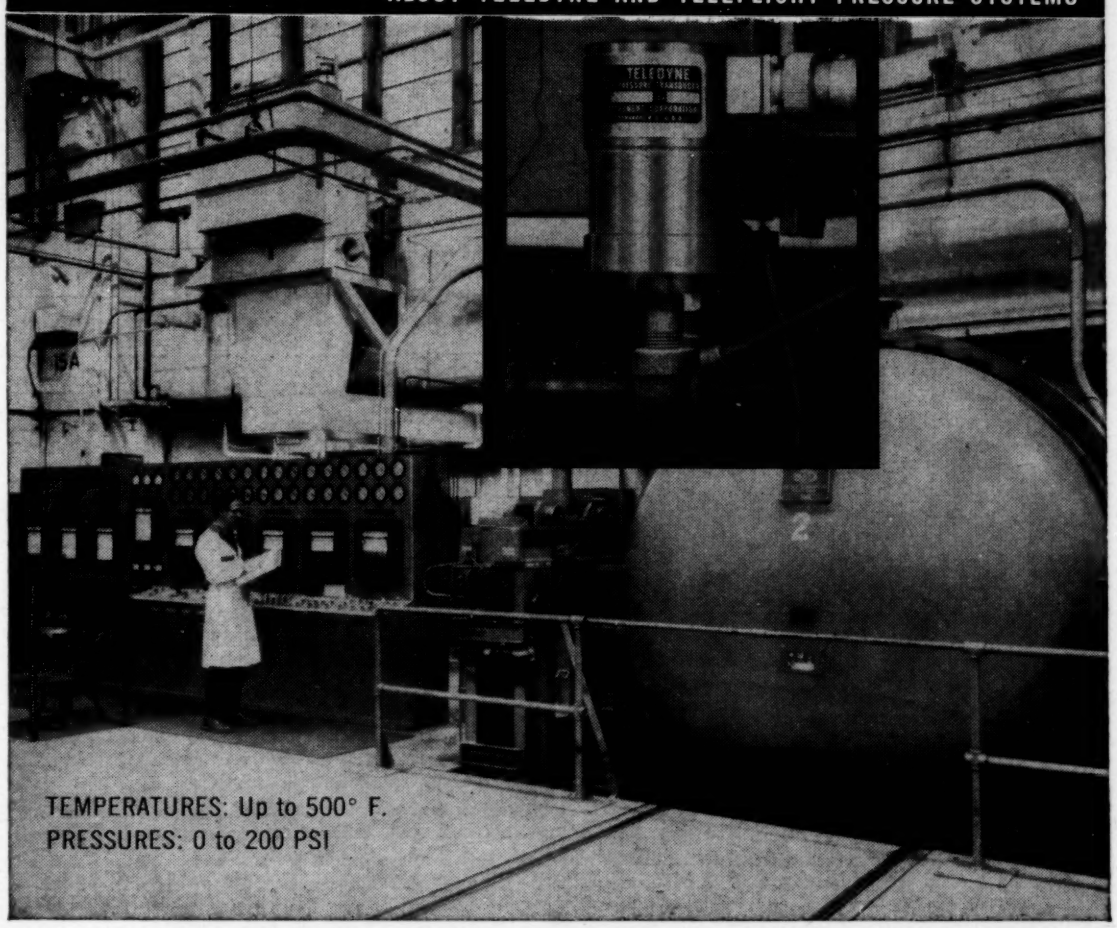
ABOUT TELEDYNE AND TELEFLIGHT PRESSURE SYSTEMS



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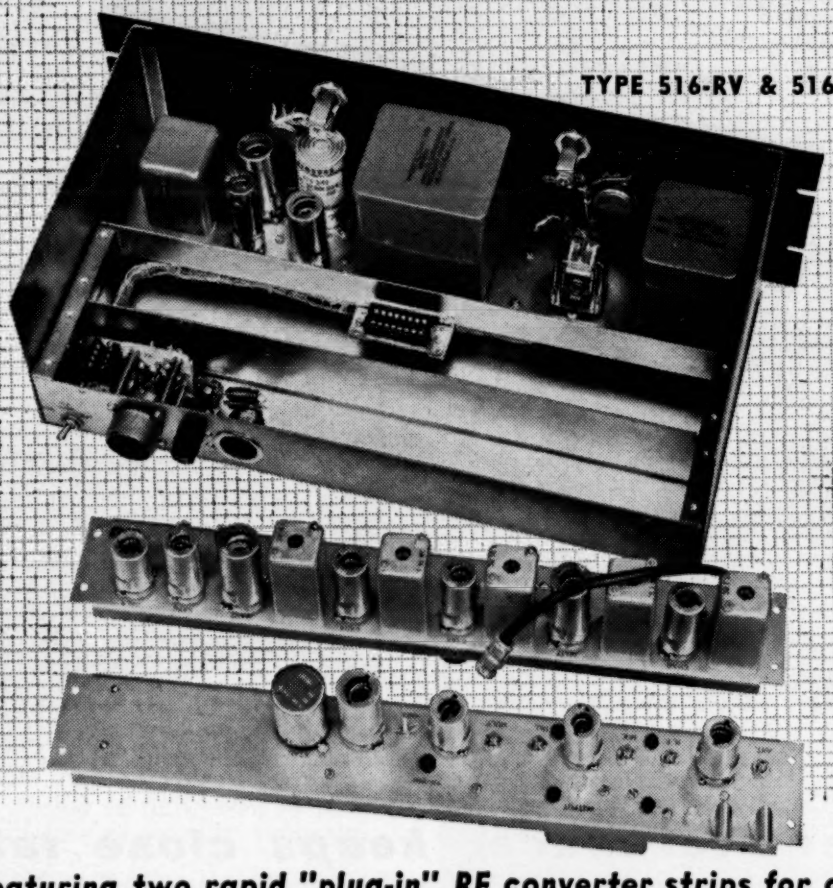

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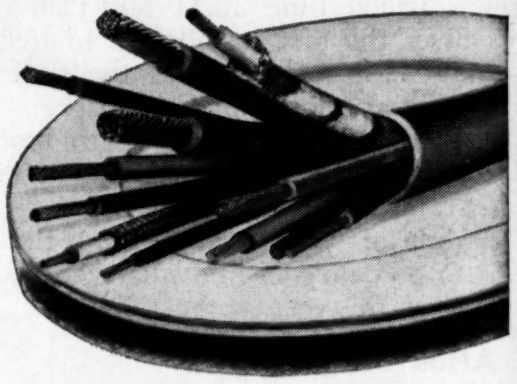

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Martin is active in many areas of space research: space flight vehicles, manned satellites, nuclear rockets, thermoelectric power generation, guidance systems, thermal shield materials, interplanetary communications, and the life sciences.

MARTIN

AMR Studied for Support System Role

Primary goal is to provide a generalized, versatile test environment to handle contemporary programs.

Patrick AFB, Fla.—Air Force Missile Test Center, operating the Atlantic Missile Range in support of military and civilian agencies in and out of Air Force Systems Command, may be moving toward a new philosophy of range development.

Growth of the range, previously determined largely by specific requirements for specific missiles, is being studied as a support system. The primary goal is to provide a generalized test environment which must be versatile enough to handle the wide variety of contemporary programs assigned to it, and flexible enough to accommodate future projects yet undefined.

Further range growth does not necessarily mean geographic growth. With current instrumentation stations as far away as Pretoria, Union of South Africa, and impact points nearly half a world away in the Indian Ocean and reaching toward Australia, further distance-stretching seems unnecessary.

Instead, the emphasis will be on range elaboration, extending the data-taking and handling capabilities to improve the quality of the hundreds of thousands of data points measured during every test.

Changing Layout

The explosive expansion of the range that characterized its life during the first few hectic years of the space age has slowed a bit now. Range expansion is more deliberate; there is a little more time for planning.

But the work load continues to increase, having approximately doubled during the last five years. Right now, the Center launches between four and six missiles or space probes every week, with 100 to 125 supporting missions flown by aircraft, smaller probes or test vehicles.

Personnel required to handle the myriad tasks of readying and launching the complex vehicles now number 23,400, up more than 10% from last year's over-all total, and two and one-half times the working population of five years ago.

The physical plant of the range, its facilities, instrumentation and other equipment is worth over $813 million today. Spending during Fiscal Year 1961 totaled more than $276 million.

Paradoxically at first glance, the Atlantic Missile Range appears to be cutting back. Half a dozen downrange stations have been mothballed or are on caretaker status, including stations that were most active a few years ago. But the situation is not paradoxical at all; as the short-range stations are being closed out, long-range stations and new instrumentation ships are being phased in to handle the job at the far reaches of today's missile ranges.

Station Use

This change in range station use is one facet of AFMTC today that reflects changing requirements. Everywhere you look, you see other evidence that the range is in transition from a contractor shooting gallery to an aerospace support system.

Five years ago, curing concrete pads gave evidence that the range was expanding. Complexes of newly poured blockhouses and launching pads pointed the way toward the then-future Atlas test firings. The four pads for the big Convair missile were later upstaged by the same number for the Martin Titan missile.

Now from the top of a 20-story Saturn gantry of red steel, laced into the blue sky, you look down along the missile row, nine tiny pads far below your eye level. At this point, more than anywhere on the range, the observer is struck by its changing character.

Below, a double line of railroad roadbeds, laid at the cost of $1,800 per running foot, stretch toward the launching pad. Bulky concrete monoliths support bright yellow and red steelwork, the holding and bracing fixtures for the huge Saturn space booster. All around the pad, the contoured ground outlines blockhouses, fuel bunkers, water lines and cables.

From the steel grid under your feet it is more than 280 ft. down to the ground. Between those two levels are a dozen or more work platforms, each working like an elevator between the limits set by platforms above and below it, and each contoured to fit the shape of the Saturn.

Down on missile row, one pad will handle the Atlas-Centaur, the space booster with a liquid hydrogen-liquid oxygen upper stage.

But space shots, while they may become the preponderant portion of tomorrow's range programing, today share range time and facilities with a host of other agencies.

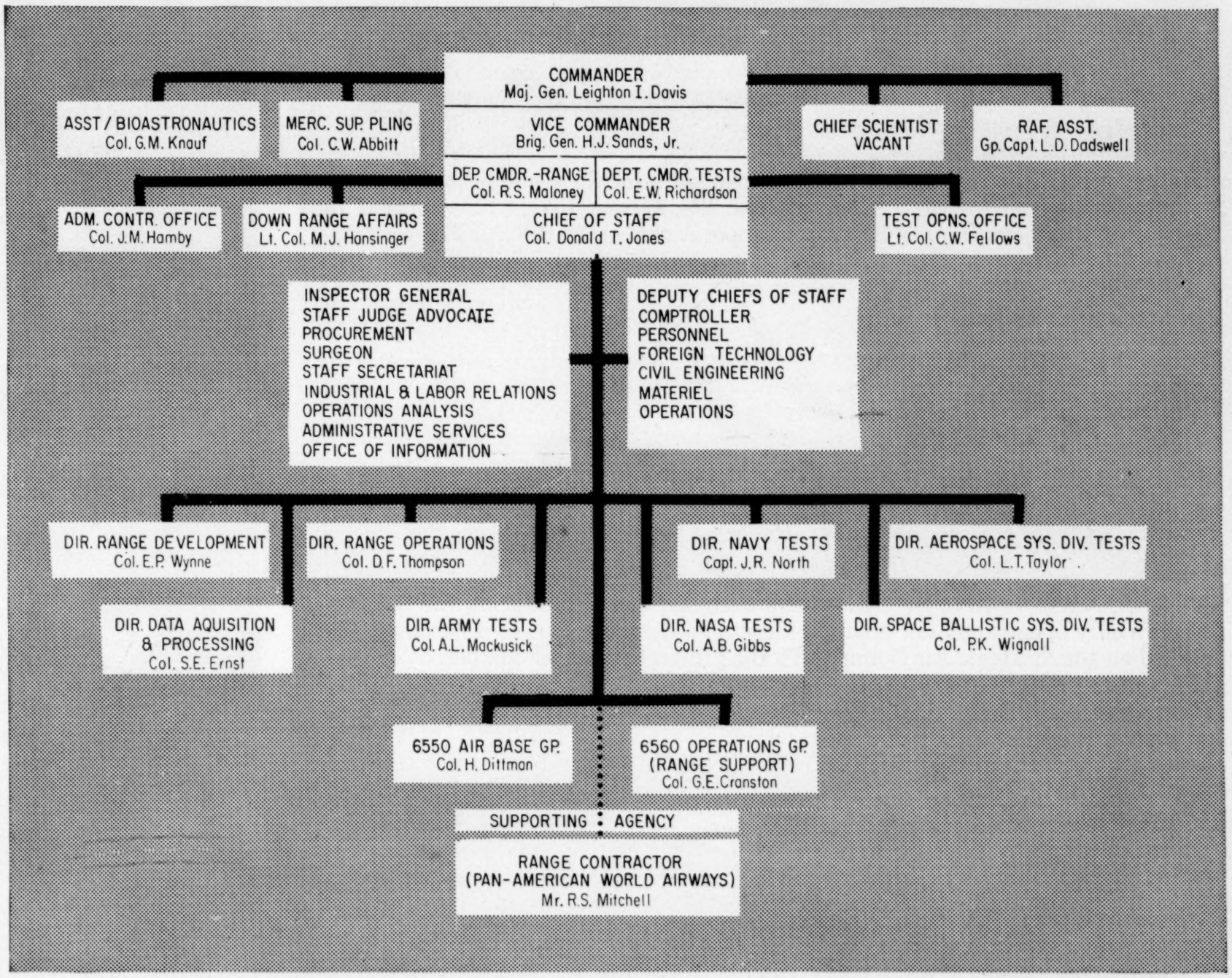
Range Programs

AFMTC cooperates in range programs with:

- **Army's Nike Zeus** anti-missile project. Radars developed for the Army program are sited on Ascension Island, with the primary aim of tracking ballistic missile firings from the Cape for experience. These radars feed their data to AFMTC as part of any ICBM test firing they track.
- **Navy Polaris** fleet ballistic missile project. Polaris test rounds are fired within sight of the AMR instrumentation. Ships from the Navy unit dock at Port Canaveral during the actual program.
- **Advanced Research Projects Agency** (ARPA). Most of the work being done by ARPA on the range involves infrared measurements of missile traces.
- **Canada.** Two Avro CF-100s of the Royal Canadian Air Force have been modified to do infrared work and are operating from Patrick Air Force Base

Maj. Gen. Leighton I. Davis, Commander, Air Force Missile Test Center, AFSC . . . born in Sparta, Wis., 1910 . . . graduate U. S. Military Academy, 1935 . . . received his wings, 1936 . . . assigned Sixth Pursuit Squadron, 18th Air Group, Hawaii . . . instructor, West Point, 1942 . . . duties with AMC, Wright Field, 1949 . . . Air War College . . . commandant, Air Force Institute of Technology, 1951 . . . director of development, ARDC, 1954 . . . transferred to Holloman AFB, N. M., as commander, Missile Development Center . . . returned to Hqs. ARDC as Deputy Commander for Research, 1958 . . . re-assigned to Hqs. USAF as Assistant Deputy Chief of Staff, Development.

USAF Missile Test Center Organizational Chart



during missile launch programs.

• **Tactical Air Command.** The Martin Mace TM-76A surface-to-surface tactical missile is undergoing Category III tests on the AMR. Missiles are launched from surface sites, built like the subsurface hardened sites that will house the missiles in the field.

• **United States Air Forces Europe** (USAFE). A liaison office of USAFE is maintained at the Cape for Italian troop training in the firing of Jupiter ballistic missiles.

• **National Aeronautics and Space** Administration (NASA). This organization, charged with responsibility for Project Mercury, uses the AMR and its support facilities extensively during its entire program.

Range Layout

The Atlantic Missile Range starts at the launching pads on Cape Canaveral, about 18 mi. north of Patrick AFB, and extends eastward for about 10,000 naut. mi. to 90 deg. east longitude. Five years ago, the range had just become fully instrumented—by contemporary standards—over a distance of 1,500 mi., down to St. Lucia island. Plans were under way to extend the range to Ascension Island, 5,000 mi. away from the Cape. There were 10 stations on the range to St. Lucia then, starting with Canaveral AAFB, (Auxiliary Air Force Base) and passing Jupiter AAFB, Grand Bahama AAFB, Eleuthera AAFB, San Salvador AAFB, Mayaguana AAFB, Grand Turk AAFB, Dominican Republic AAFB, Mayaguez AAFB and finally St. Lucia AAFB.

Now alternate bases have been eliminated. The list of range stations now includes the Cape, Grand Bahama Island, San Salvador, Grand Turk, Antigua, Ascension Island and Pretoria.

This complex is operated by Pan American World Airways under contract to the AFMTC. PanAm's responsibility extends to administration and housekeeping; the technical work of data collection and handling is being performed by Radio Corp. of America under subcontract to PanAm.

Military command of the downrange stations is now in the hands of officers with a background in research and development.

They monitor the contractors and make all the contacts with local governments.

The one range operation not delegated by the AFMTC is range safety. The Air Force maintains control over the destruct button.

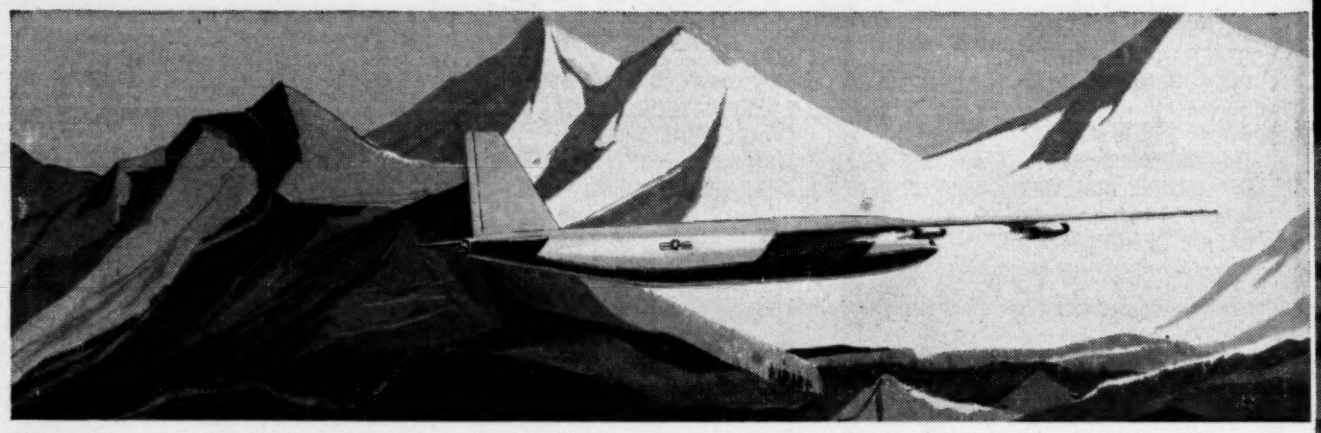
Instrumentation

Four impact areas, instrumented with underwater sound equipment, are located near Grand Turk, Antigua, Fernando de Noronha, an island off the coast of Brazil, and Ascension Island. RCA operates the systems at Fernando and Ascension; the Navy operates the other two facilities.

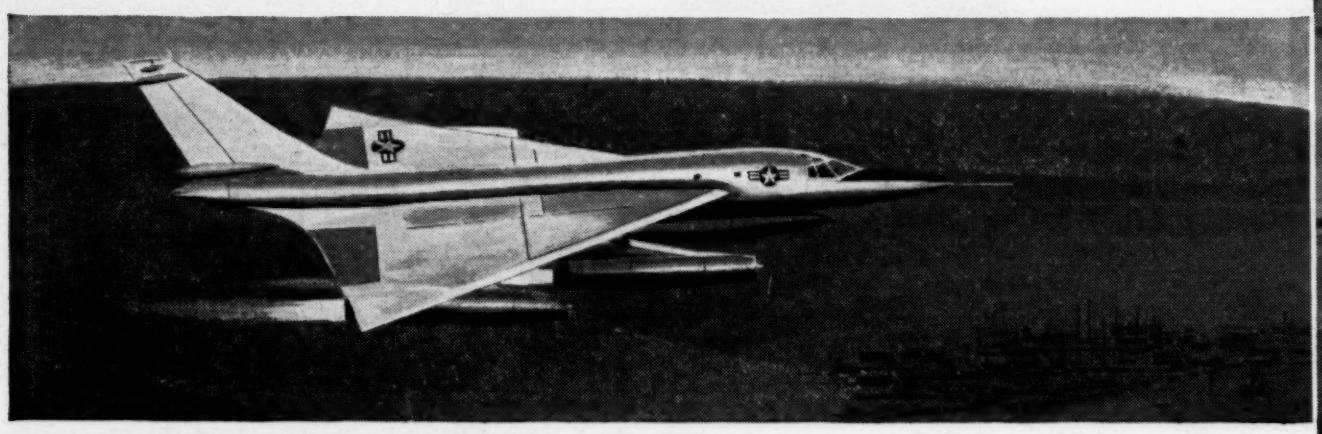
Eight instrumentation ships, equipped to record telemetry and to recover nose cones or data capsules, supplement the island stations. Further support comes from a fleet of aircraft.

Nine Douglas JC-54s are used,

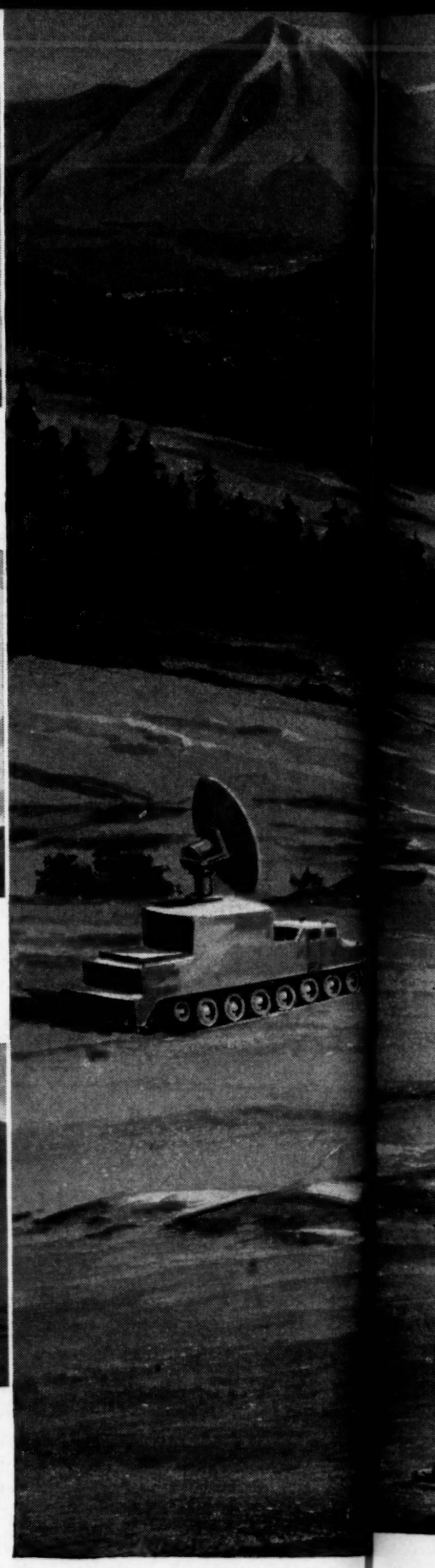
NAVIGATION — Raytheon in 1958 developed a highly sophisticated Doppler Navigation System for the U.S. Navy's A3J. This system was the forerunner of an advanced Raytheon Doppler System now operational in the U.S. Air Force's B-58.



TERRAIN AVOIDANCE — Raytheon designed and is producing the U.S. Air Force's only operational low-altitude target acquisition radar. It is currently installed on the Strategic Air Command's B-52 intercontinental bomber.



BOMB-NAVIGATION SYSTEMS — Raytheon developed and produced an integrated radar-radome for the high performance B-58. With the Raytheon Doppler System (the most accurate in use today, despite severe environmental conditions) these radars are vital elements of the Hustler's bomb-navigation system.



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U. S. Navy's SPARROW III missile systems; as producer of the 2nd generation Polaris' advanced guidance system; and as systems manager of the ARPAT Terminal Defense System program.

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PROBLEMATICAL RECREATIONS 85

Dr. Reed, arriving late at the lab one morning, pulled out his watch and said, "I must have it seen to. I have noticed that the minute and the hour hand are exactly together every sixty-five minutes." Does Dr. Reed's watch gain or lose, and how much per hour?

—Contributed

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ANSWER TO LAST WEEK'S PROBLEM: Squaring $X + Y + Z = 1$ we have: $X^2 + Y^2 + Z^2 + 2XY + 2YZ + 2YZ = 1$ or $XY + YZ + XZ = \frac{1}{2} - \frac{(X^2 + Y^2 + Z^2)}{2}$. Even if X, Y or Z should be negative their squares must be positive; hence the expression in brackets must be positive.

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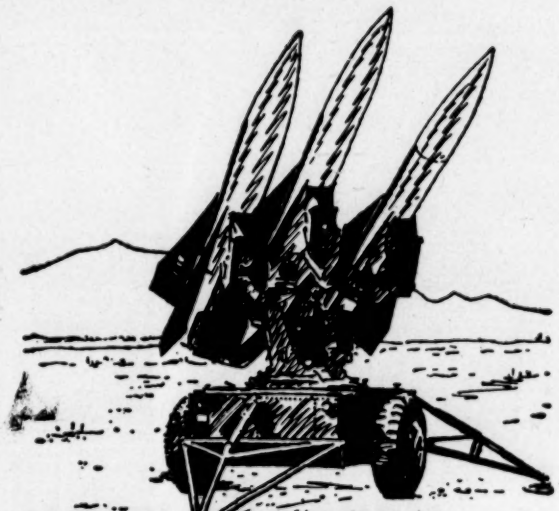

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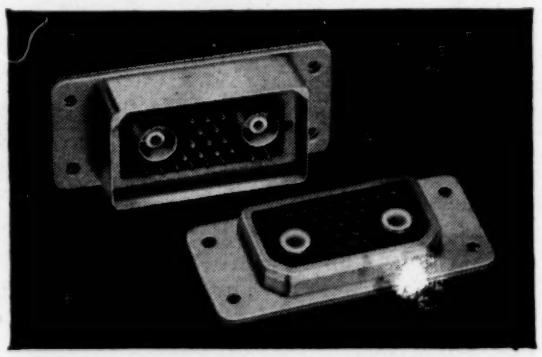

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equipped to receive and record telemetry, and to make other electronic or photographic records of missile flights. They can also detect nose cones or data capsules in the water after impact.

The JC-54s work with the range ships during recovery and provide directional information so that the ships can make the actual retrieval.

Six Convair JC-131 aircraft, equipped to detect and locate interfering electromagnetic radiation, also work during range firings. They can also handle the equipment normally installed on the JC-54s and perform the same kind of job within the limits of their operating radii.

Future mobile instrumentation or tracking stations will include Lockheed JC-130s with infrared detection equipment, able to operate at higher altitudes and longer range than either the JC-54 or JC-131.

Two additional surface ships are now being converted for future range requirements, and a third is planned for this fiscal year. The ships will mount L-, C- and X-band radars; infrared acquisition gear; telemetry; single-sideband communications equipment; and a high-precision navigation system.

A communication station has been set up at a temporary site in the Union of South Africa to link the Cape and range ships in the Indian Ocean.

Beyond the land mass of South Africa, operations involve a pair of difficult problems. The first is communications, which must span the great distance between the Cape and the recovery elements in the impact area. The second is diplomatic clearance to enter an area, which is difficult to time correctly in the request because of the uncertainties in the launch schedules.

By Fiscal Year 1966, AFMTC expects to be using communications satellites with 10-to 15-megacycle bandwidths.

The need to elaborate on the range instrumentation, plus the "support system" concept for the growing range, means that some new instrumentation must be developed for generalized range requirements, rather than for specific missiles. Two good examples of currently planned instrumentation to meet future needs are Mistram, an X-band, CW radar system for precision measurements of trajectory data, and PORT, a photo-optical recorder tracker system.

Primary use for Mistram will be in furnishing input data for the range safety job; PORT will give photographic coverage of sequential events, such as staging, separation or breakup of missiles.

Measurement Requirement

Mistram grew out of a requirement to measure burnout velocities and impact points with accuracies better by an order of magnitude than those currently accepted on the range. For example, burnout velocities are now measured to accuracies of about two or three feet per second; Mistram will improve that value to about 0.1 ft./sec. Impact points will be predicted so that the circular error probability (abbreviated CEP and defined as the radius of a circle inside which half of the number of missiles will impact) can be measured to 0.1 naut. mi. at a distance downrange of 8,500 mi.

Space position date, now measured to approximately plus or minus 20 ft. with the FPS-16 tracking radar, will be measured to 0.4 ft. with Mistram.

Mistram, which was developed by General Electric Company's Defense Systems Dept., uses interferometer

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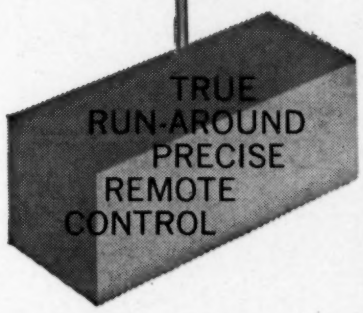

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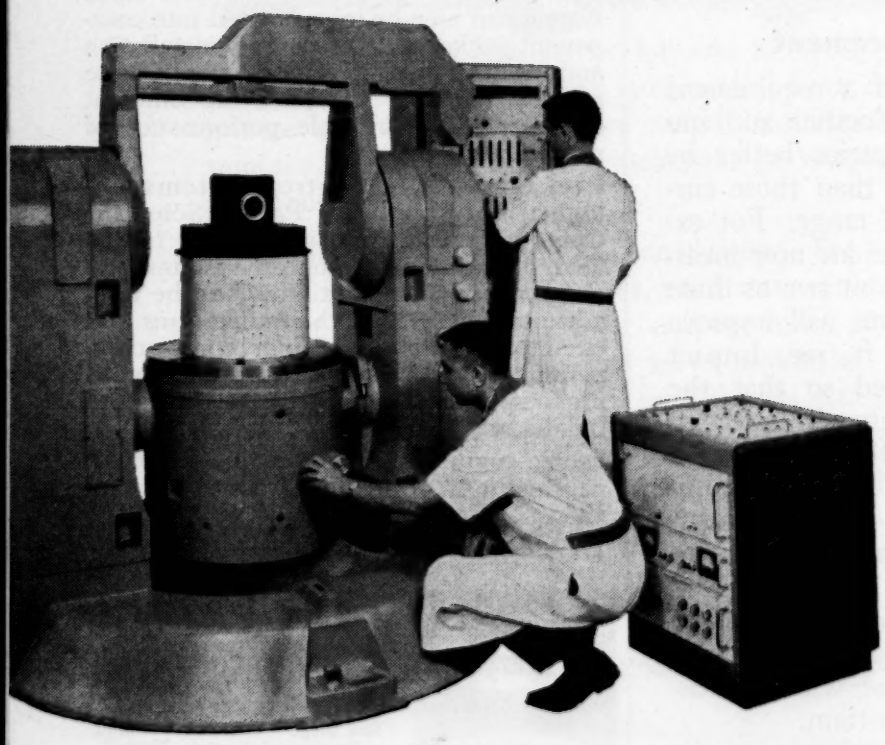

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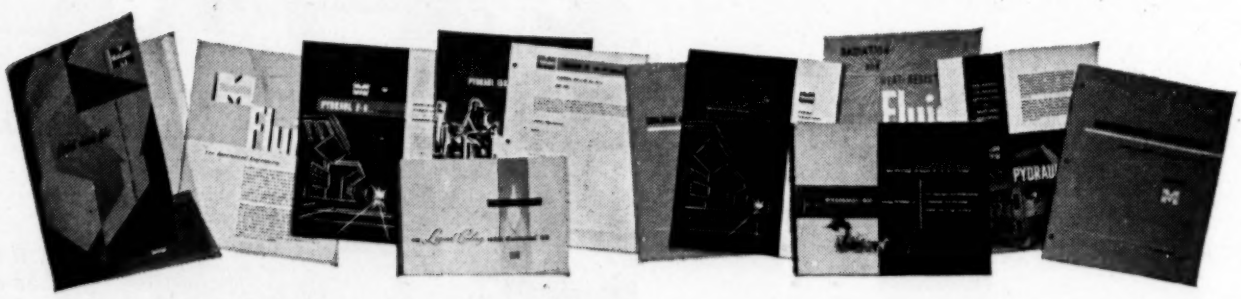

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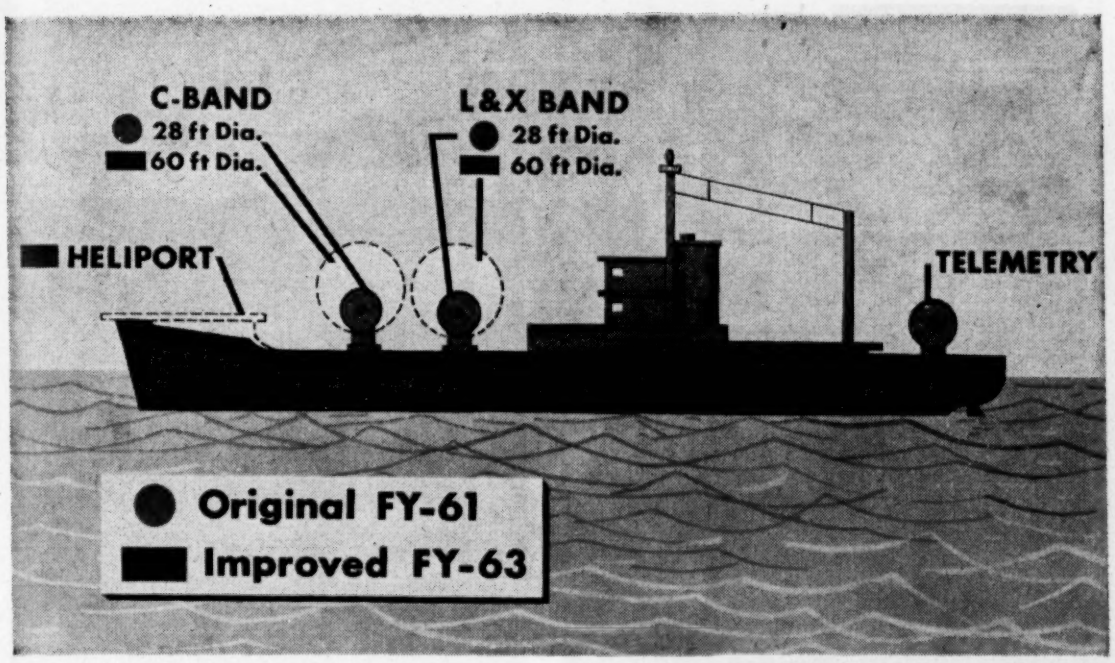
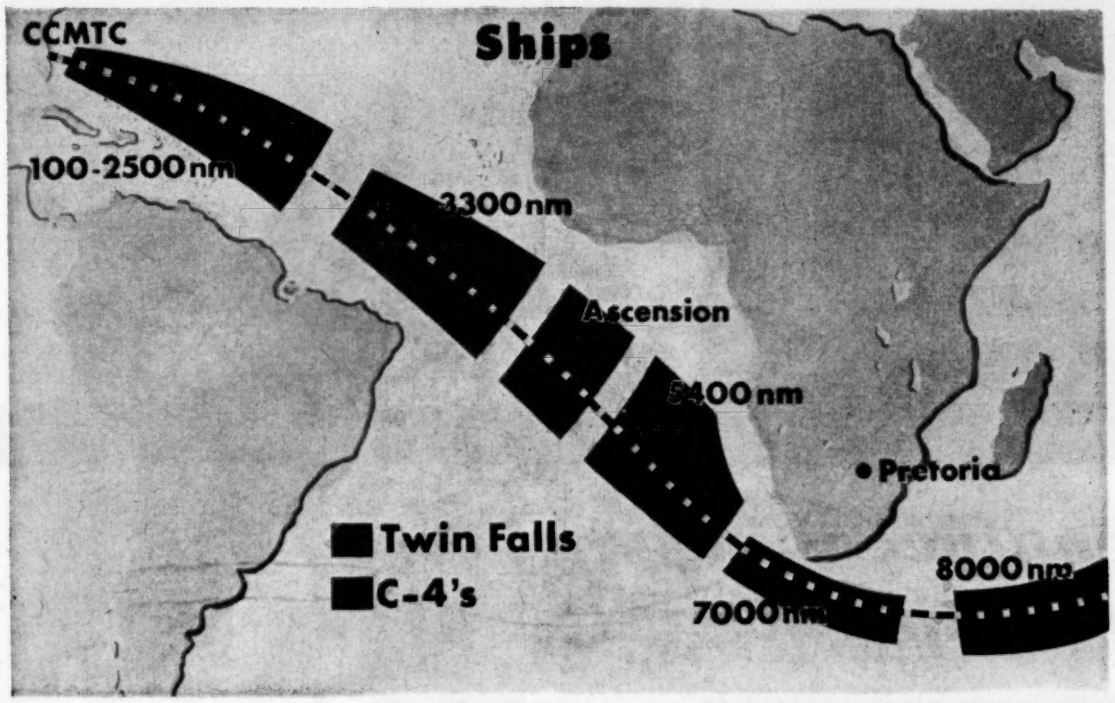
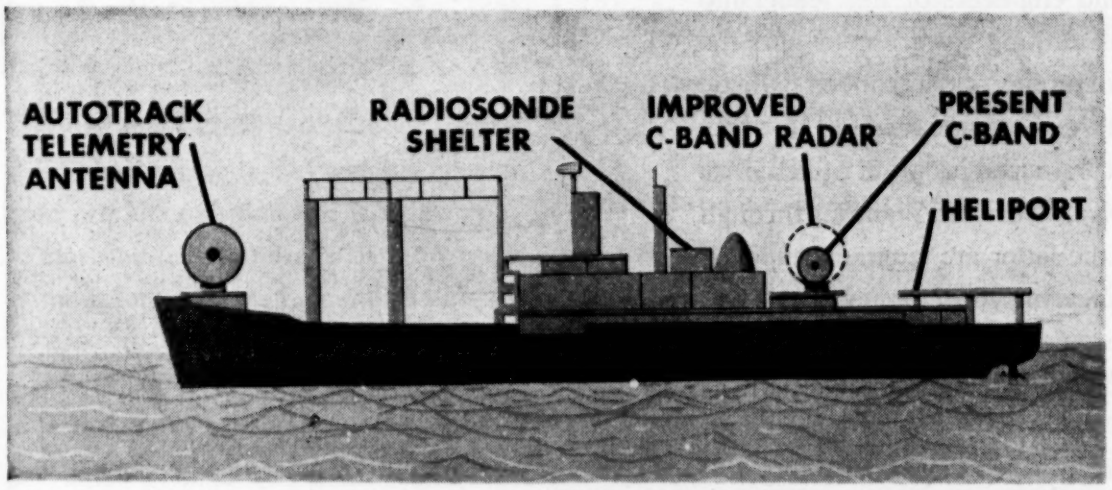


C-4 SHIP INSTRUMENTATION



RANGE COVERAGE BY SHIP-BASED INSTRUMENTATION



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radar techniques and triangulation to give velocity and position data, and presents this data in real time so that there is no time lag in the system to delay or confuse range safety decisions.

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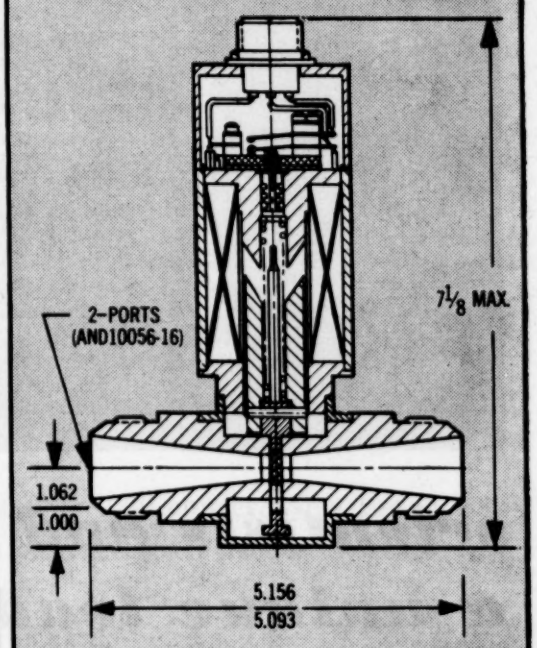

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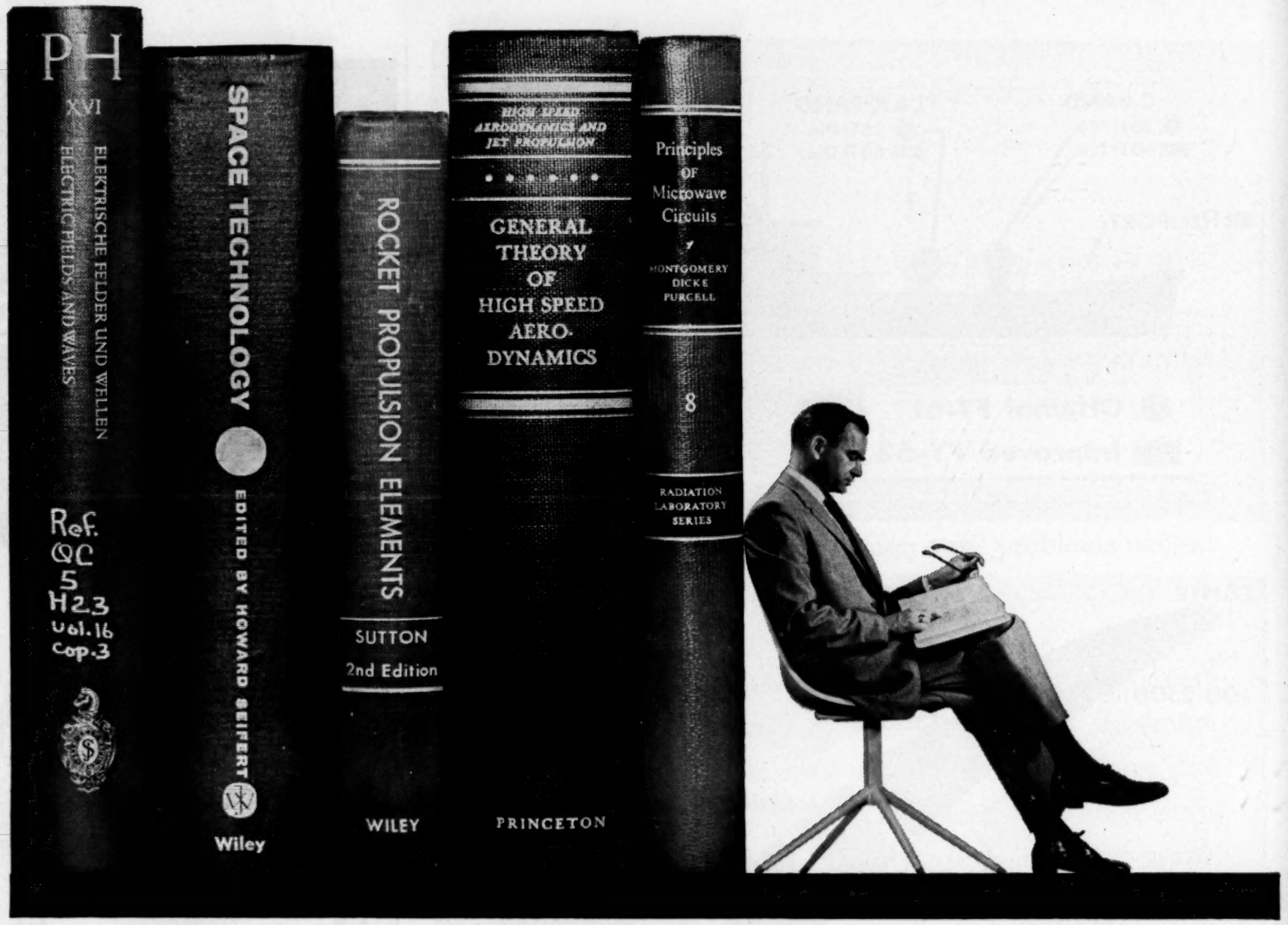

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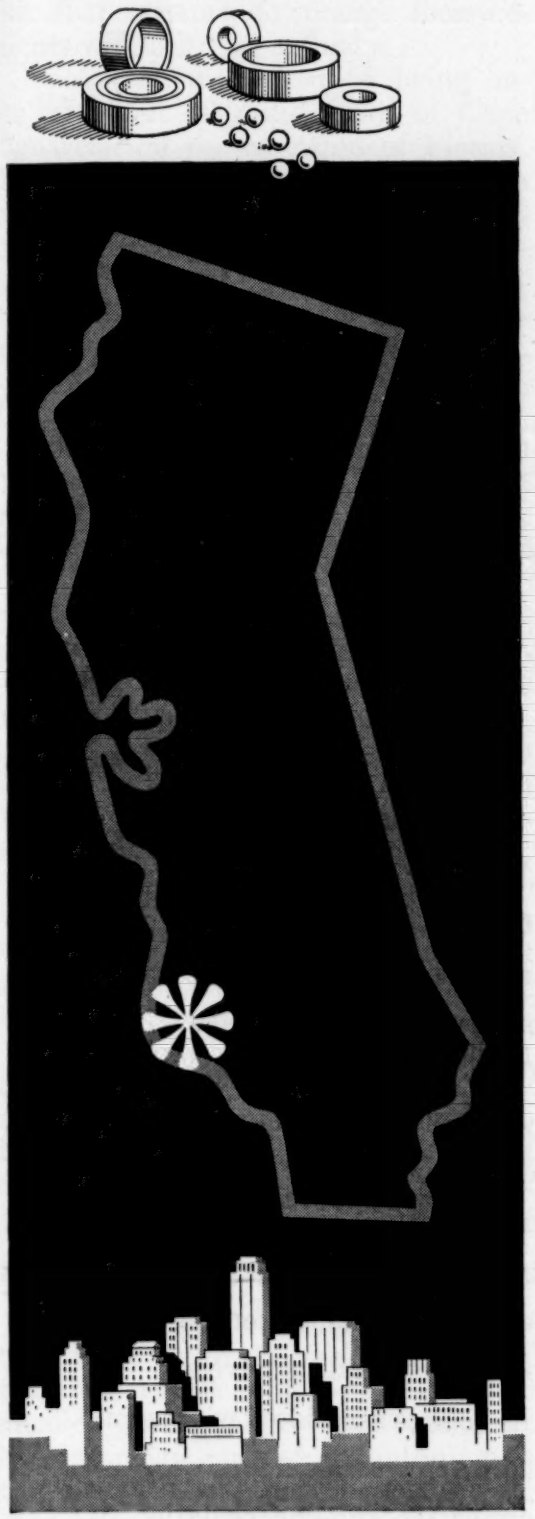

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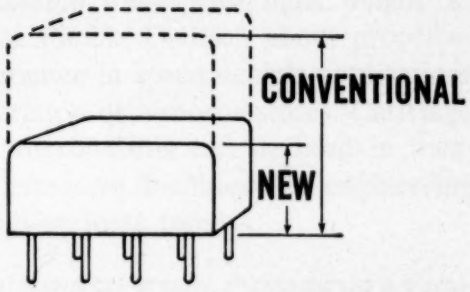

REVOLUTIONIZES PRINTED CIRCUIT PACKAGING

It's only .400 inches high. Weighs only .250 ounces. New Leach M-250 is so tiny it uses less than half the space needed by standard subminiature crystal can relays!

Space is saved on printed circuit boards because three M-250s will replace one ordinary, horizontally-mounted crystal can relay. And with its 0.2-inch terminal spacing and internal terminal connections, it is interchangeable with conventional crystal can relays.

Simplified design, mechanized production with minimum human contact, rotary balanced armature design and small space requirement—four reasons why you should specify Leach Half-Size Crystal Can Relays for your printed circuits (and that's just half the story!)

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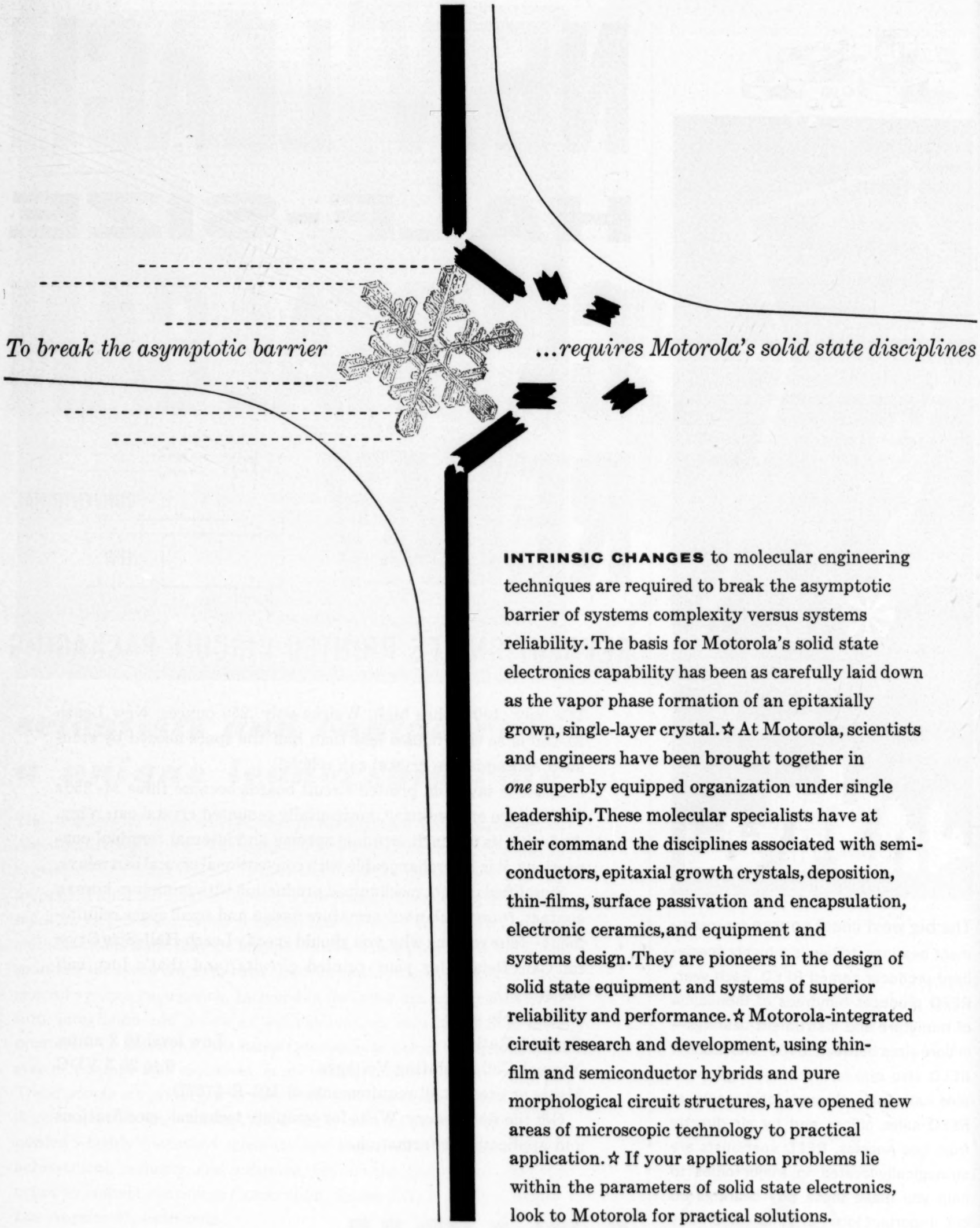

INTRINSIC CHANGES to molecular engineering techniques are required to break the asymptotic barrier of systems complexity versus systems reliability. The basis for Motorola's solid state electronics capability has been as carefully laid down as the vapor phase formation of an epitaxially grown, single-layer crystal. ☆ At Motorola, scientists and engineers have been brought together in *one* superbly equipped organization under single leadership. These molecular specialists have at their command the disciplines associated with semiconductors, epitaxial growth crystals, deposition, thin-films, surface passivation and encapsulation, electronic ceramics, and equipment and systems design. They are pioneers in the design of solid state equipment and systems of superior reliability and performance. ☆ Motorola-integrated circuit research and development, using thin-film and semiconductor hybrids and pure morphological circuit structures, have opened new areas of microscopic technology to practical application. ☆ If your application problems lie within the parameters of solid state electronics, look to Motorola for practical solutions.

Military Electronics Division MOTOROLA

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burnout ranges for conceivable missiles, but that extreme downrange measurements will lack that accuracy.

The Mistram system is being installed about 30 miles south of Cape Canaveral on the mainland of Florida. The central station, at the intersection of the two base lines, has been accepted by the Air Force; the four remote stations—two at 10,000 ft. from the central station and two at 100,000 ft.—are to go through acceptance shortly. Operational date is estimated as April, 1962.

One of the limiting factors in the Mistram system is the accuracy with which its base lines can be surveyed. Refraction of the line of sight, caused by differences in air density near the ground, is the major reason for inaccuracies in precision surveying.

Another problem is that as the missile approaches burnout at high altitude, its exhaust flame has ballooned to blanket an enormous chunk of sky with highly ionized particles that make communications difficult. For this reason, AFMTC is negotiating to install one of the Mistram systems downrange at Eleuthera Island so that a better look angle can be obtained at the critical phase of the missile's trajectory.

Initial acquisition of the target can be fed to the Mistram system either by optical trackers or the FPS-16 radar. Readout from Mistram can be in digital form and can be fed directly to computers for handling.

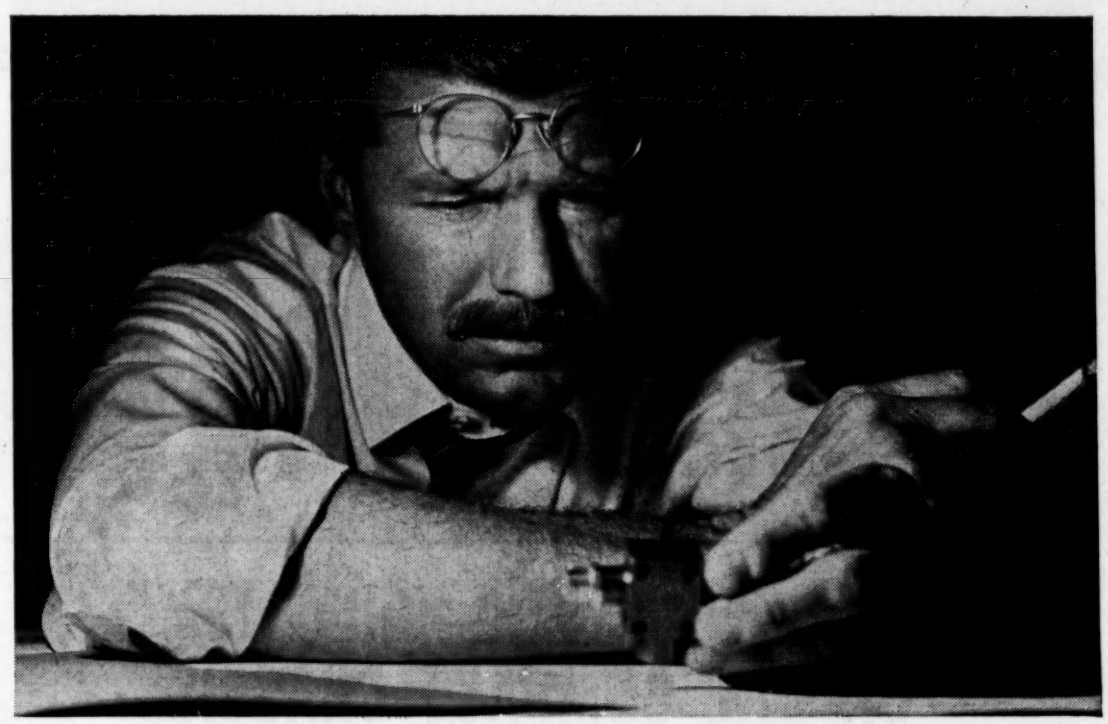
Photo-Optical System

The major purpose of the PORT system is to improve the accuracy of recording events which contribute to missile development. For example, tracking radars can give the information that a test missile has broken up, but only photographic or optical instrumentation can tell how or in what sequence the missile failed.

The chief characteristic of the PORT system is that it pushes the state of the art forward in several respects. It is to be a mobile, air-transportable, completely self-contained system, capable of being used anywhere in the world. It will have a 1,000-in. focal length, 40-in. aperture optical telescope as its primary sensor, with completely automatic target acquisition aids, focussing and exposure controls. Data will be recorded on 70-mm. film.

Current status is that proposals to meet PORT requirements have been received and are being evaluated. AFMTC intends to finance the development of the first prototype before going further into procurement of successive units.

Image enhancement techniques are asked for in the proposal requests, as well as consideration of means to improve the image contrast.



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If your problem involves combining a sizeable force with light weight for positive, instantaneous operation, talk to the Pacific Division about propellant actuated devices. We have a wealth of experience in space vehicle applications, aircraft escape systems and ejectors for separation of airborne stores. Cartridge-actuated pin valves, pin pullers and other mechanisms can be used in many ways to accomplish a specific task. Our extensive facilities for engineering, manufacturing and testing are available. Call or write today.

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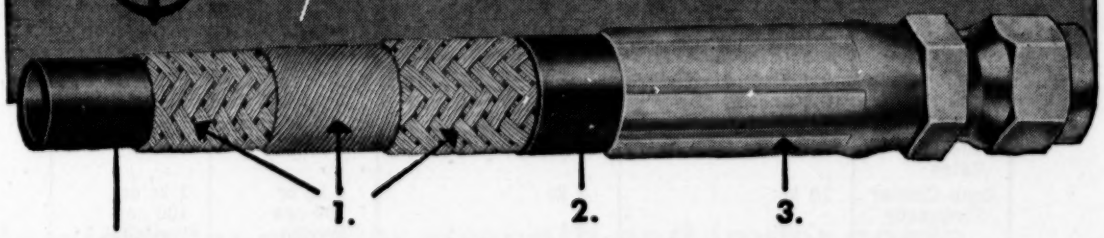
NEW from ANCHOR®

hdp Hose Assemblies for Aircraft, Missile H.P. Pneumatic Servicing



hdp high density polyethylene inner tube

50 ft. lengths can be fabricated! Polyethylene is easy to clean and is highly resistant to the effusion of gases.

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2. Neoprene cover to withstand rough handling and exposure.

3. Anchor exclusive stainless steel, ductile sleeve swaged couplings are leak-proof and permanent! Couplings have 37° female swivel nuts to mate with MS33656 fitting ends.

The Anchor hdp Hose Assemblies fully conform to MIL-H-26666A (USAF) specifications: Available in the -4, -8, -12 size for *4,000 PSI W.P.* and in the -6 size for *6000 PSI W.P.* Temperature range -65°F to +160°F for service with any inert gas. Request our new MIL-SPEC. CATALOG now!

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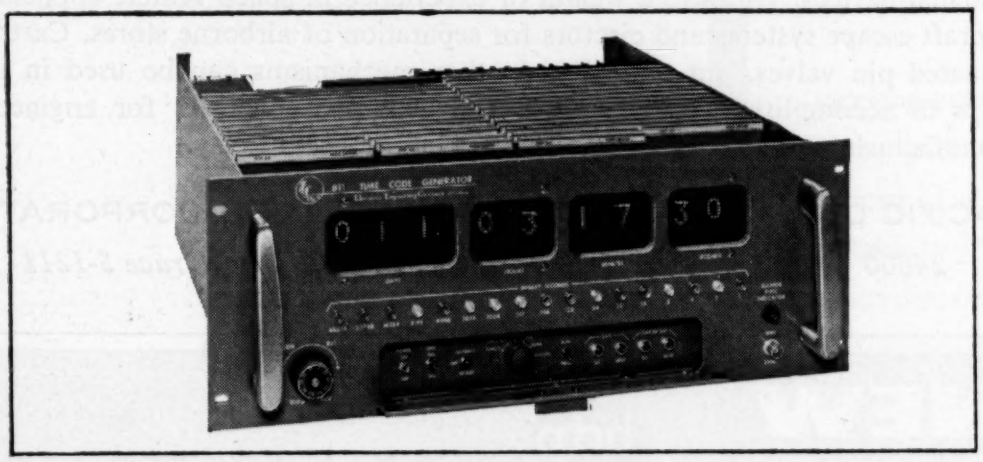

EECO 811 IRIG FORMATS

	A	B	C	D
Time Code Format	34 Bit BCD Code identifying days, hours, minutes, seconds and 1/10 seconds and a 17-bit binary code identifying time of day in seconds.	30 Bit BCD Code identifying days, hours, minutes, seconds and a 17-bit binary code identifying time of day in seconds.	23 Bit BCD Code identifying days, hours and minutes.	16 Bit BCD Code identifying days and hours.
Code Frame Length	0.1 second	1 second	1 minute	1 hour
Code Scan Rates	1000 pps	100 pps	2 pps	1 ppm
Code Carrier Frequency	10 kc	1 kc	1 kc or 100 cps (switch selection)	1 kc or 100 cps (switch selection)

An all solid state, card construction, precision "metronome" for the most demanding range or laboratory instrumentation. Supplies all four serial IRIG time-code formats with an accuracy of better than 1 second a month. Frequency stability is 1 x 10^{-8} per day at laboratory temperatures; 3 x 10^{-8} per day throughout entire operating range of −20°C to +55°C. Parallel code output. 10 pps and 1 pps synchronizing pulses. Synchronizing pulse for controlling external control element scanner. Both digital and resolver time shift for fast, accurate synchronization with WWV or other time standard. Operates on 115v ac ±10%, 50-400 cps, 1 amp, with power supply on same chassis.

Specify small (7" x 19" x 17"), light (32 pounds) EECO 811 Time Code Generator as the heart of your instrumentation and be assured of accurate time correlation. Price $9750, less with fewer formats. Write for EECO 811 data sheet plus information on auxiliary equipment.

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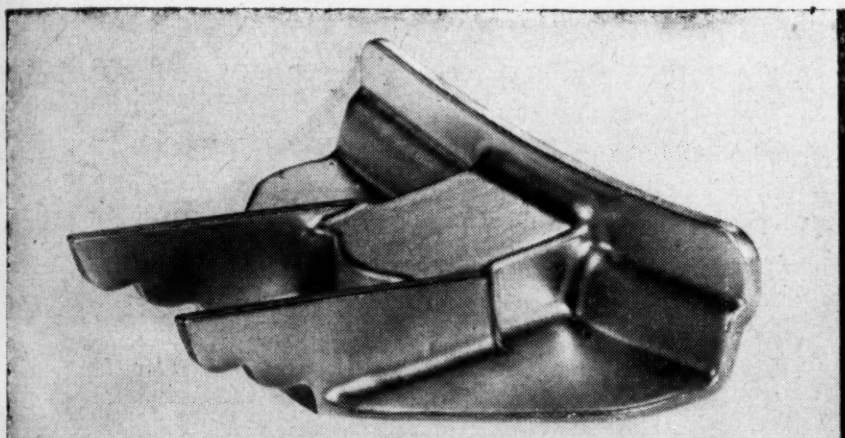
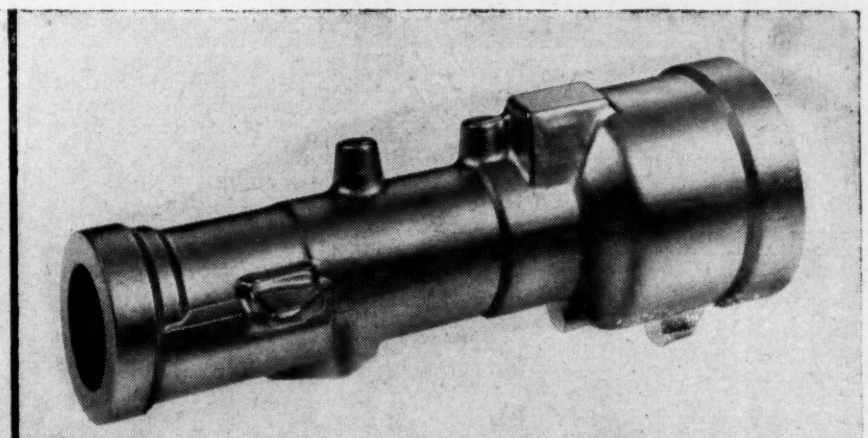
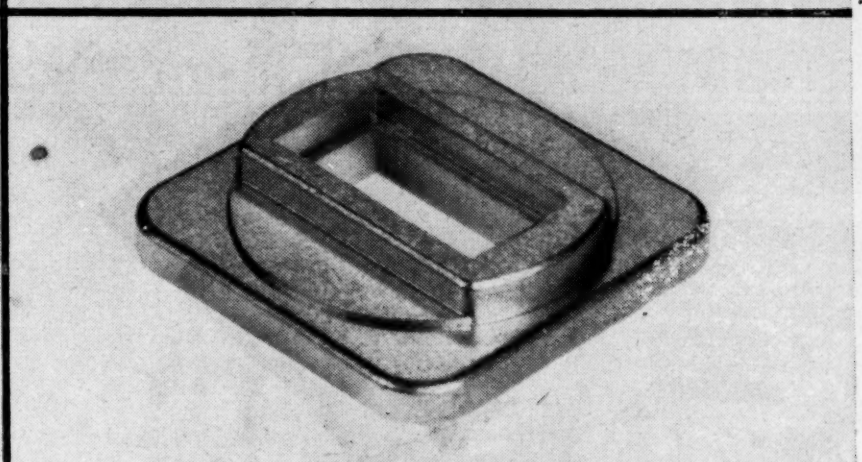


Missile hoist fitting.

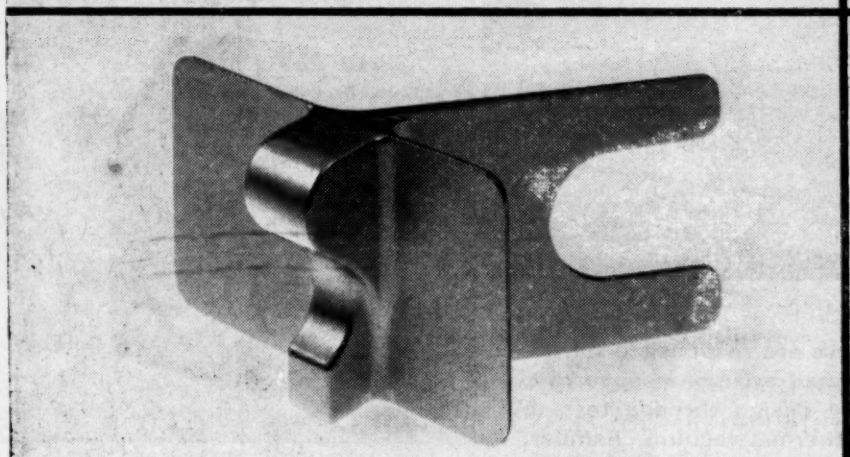


Cored seamless hydraulic fitting.

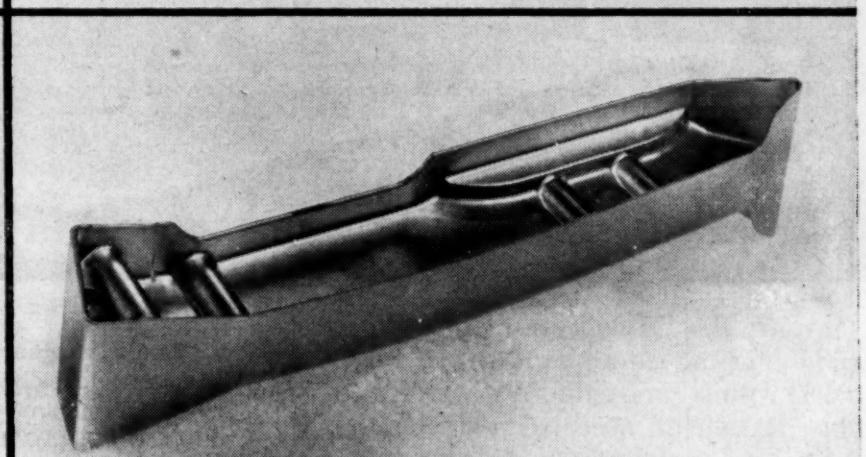
Generator bracket.



Wave guide with .0015 tolerance.



Missile component with extreme back draft on hilt area.



Door drive.

Count on machineless forgings for greater strength and lower costs

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Machineless forging eliminates the costly, time-consuming machine work required to produce precision parts from rough forgings or billet stock. It reduces material waste and provides greater strength through the retention of wrought properties and grain flow following the configuration of the part. Machineless forging provides smooth surfaces within tolerances of ±.010.

For information on how machineless forging can cut your costs write or call Altamil Defense Product Sales, 1201 South Ohio Street, Martinsville, Ind., or

Aluminum Forge Company
502 Alton St., Santa Ana, Calif.

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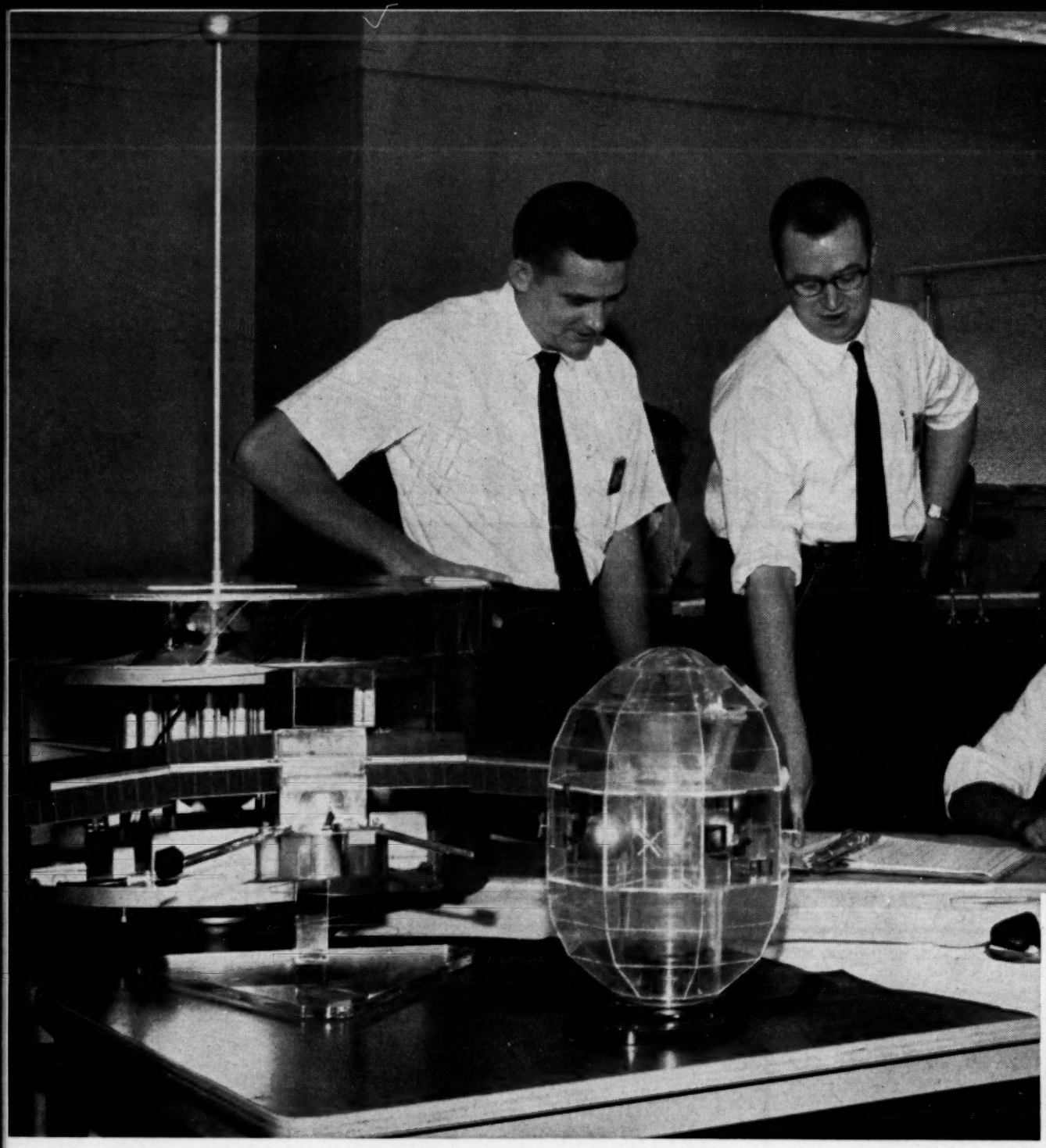

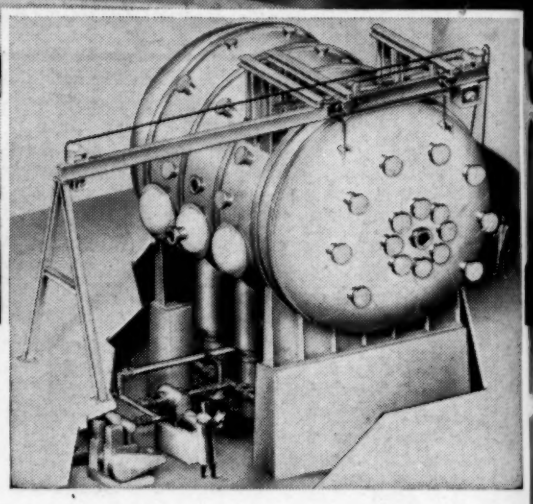

At Bendix, engineers are responsible for the complete development cycle of a spacecraft, from a preliminary design through test in our new 20′ x 27′ thermal vacuum chamber.

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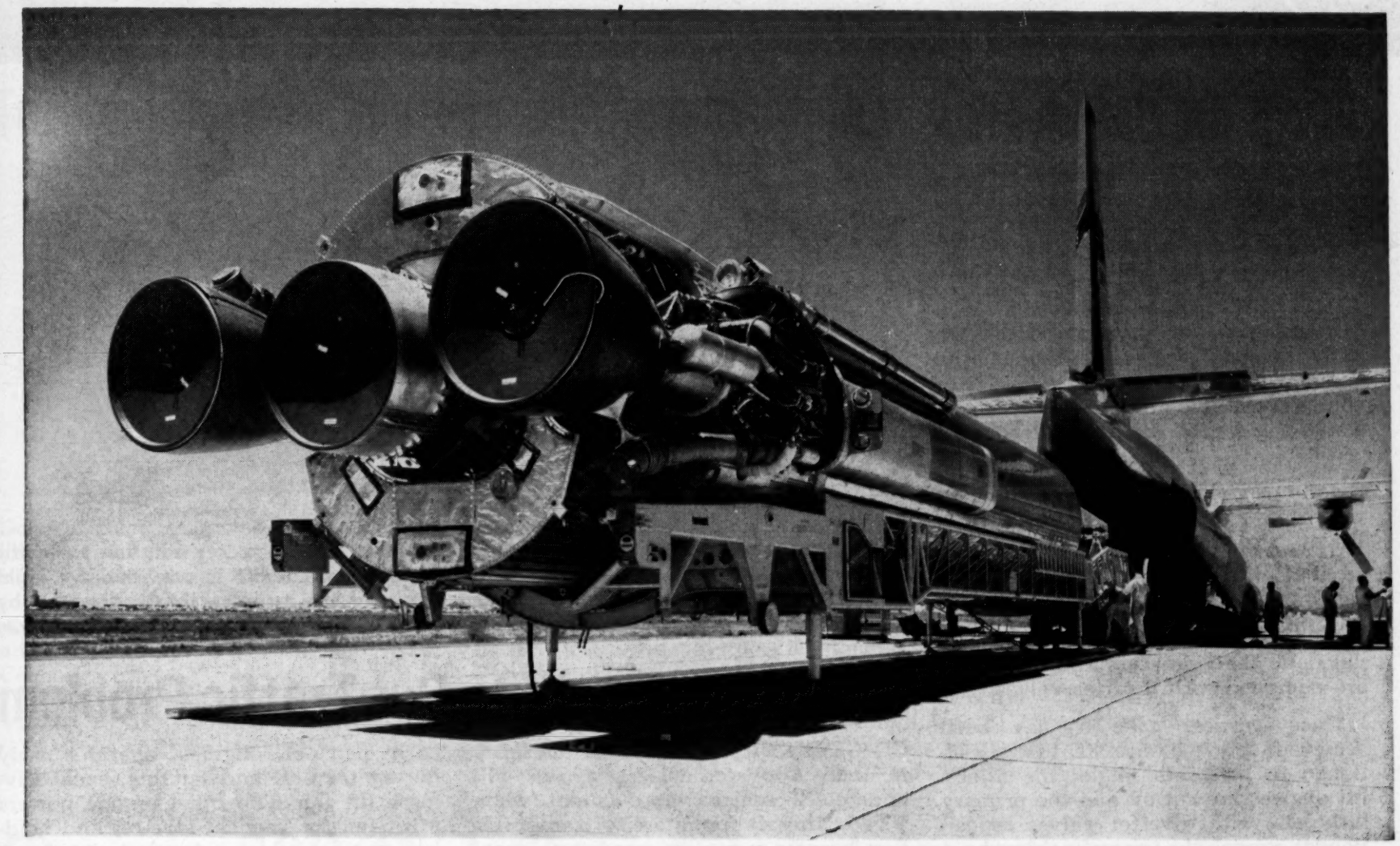


ATLAS F-SERIES missile is loaded aboard a C-133B aircraft at Miramar NAS, San Diego, Calif., for shipment to Cape Canaveral, Fla.

Vandenberg Coordinates Ballistic Effort

Vandenberg AFB, Calif.—Transition of Ballistic System Division's research and development effort to operational ballistic missile systems is centered at this Strategic Air Command base. BSD's responsibilities at the base range from construction of ballistic missile facilities, installation and checkout of equipment, demonstration, formulation of technical data and assistance, down through R&D Category II tests for the operationally configured system. In this huge job of making operational-type equipment function satisfactorily, concurrency is the critical factor—coordinating simultaneous efforts of personnel and phase-in of equipment and test procedures relating to activities of Air Force Systems Command, SAC, and contractors.

The 6565th Test Wing (Development) at Vandenberg AFB, under the administrative jurisdiction of the Air Force System Command's Space Systems Division, exercises a command control for Systems Command activities, but BSD exercises an operational control through the test wing's Deputy for Ballistic Systems. Under this deputy, Atlas, Titan, Minuteman, and Nike Zeus divisions function, as well as a Category II test force for each of the missile systems. Under the test director for this test force, representatives of SAC, Air Force Logistics Command, Space Technology Laboratories, Air Training Command and associated contractors are integrated.

A total of about 404 personnel comes under the management of the 6565th test wing for both BSD and SSD, dividing into 70 in the Office of Deputy for Ballistic Missiles, 260 in the Deputy for Space Systems Division, and 74 for staff and headquarters squadrons. There are about 7,000 contractor personnel associated with Atlas, Titan, Minuteman, Discoverer, Thor, Midas, and Samos projects. Facilities include about 39 different forms of emplacements for both BSD and SSD. All missile installations are operationally configured.

Tentative Plans

Tentative plans call for the construction of six Minuteman silos at Vandenberg, but only five may actually be built. Each silo will have its own launch control facility, be used for Category II testing, for the engineering test program—a BSD/contractor effort, which may precede Category II testing—and for training firings, known as confidence training launches (CTL) or combat evaluation launches (CEL) conducted by SAC, which has specific missiles programed.

Titan II installations include a silo launch test facility (SLTF) for R&D tests in support of program objectives. Thus far only one launch from this facility has been made. In addition, there are silo training facilities known as TF-2, comprising three installations designated 395B, C, and D, but used in the test program. Now under construction, each of these facilities has its own launch control center.

Titan I installations include a training facility TF-1, consisting of silos 395A-1, -2, and -3. There is a single launch control facility for all three of these installations, in which the missile is housed in the silo but raised to the surface for launching. An operational silo test facility (OSTF) in which the missile was to be brought to the surface for launch was damaged substantially in an explosion during a checkout procedure and is unusable.

Atlas facilities at Vandenberg include:

- **OSTF-2,** a silo for the Atlas F, in which the missile is raised to the surface for launch.
- **576D and E,** two silo training complexes for Atlas F, in which the missile also has to be raised to the surface for launch. These emplacements, identical with operational sites in the field,

Direct-lift Jet System Studied for VTOL Use In Subsonic Aircraft

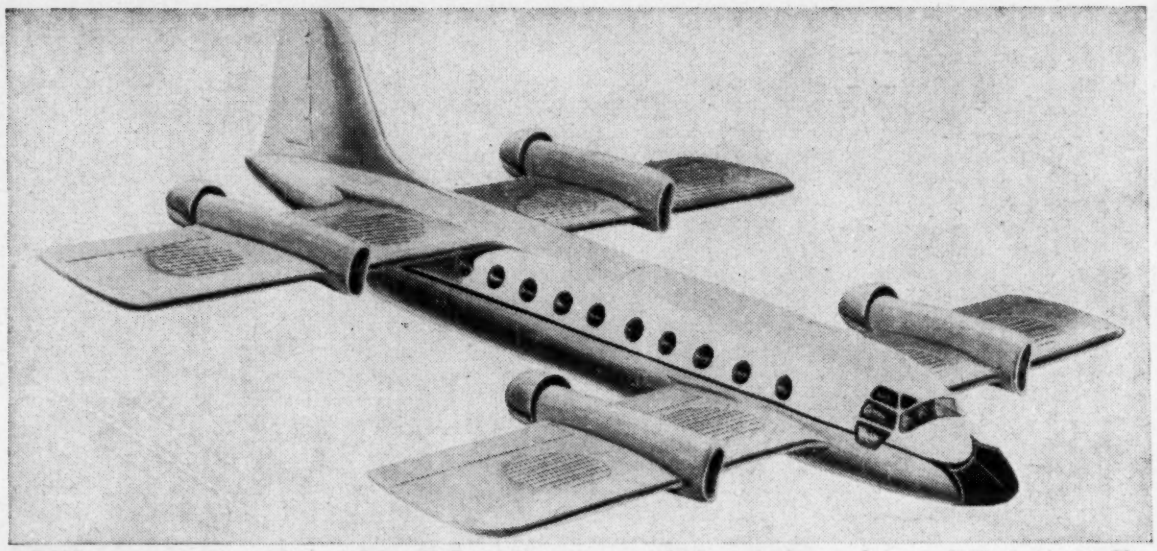
CINCINNATI, Ohio—A subsonic VTOL propulsion system that combines vertically mounted direct-lift turbojets with conventional jet powerplants is currently under study at General Electric's Large Jet Engine Department here.

In the direct-lift system, one of several VTOL propulsion techniques under investigation throughout G.E.'s Flight Propulsion Division, vertical thrust for take-off and landing is provided by small direct-lift jet engines tandem-mounted in the aircraft's fuselage. Additional vertical thrust is provided by the primary turbojets, which are equipped with diverter valves.

Once vertical take-off has been achieved and the aircraft has transitioned to horizontal flight, the direct-lift engines are cut off and the primary turbojets, with diverter valves repositioned, propel the aircraft throughout its operating radius.

An important advantage of the direct-lift VTOL system, according to General Electric propulsion engineers, is that it will eliminate the necessity of increasing the size of an aircraft's primary turbojets to obtain the increased thrust needed for take-off and landing. This, in turn, will allow optimum performance of the primary turbojets for the cruise phase of operation.

Direct-lift turbojets under study at G.E. can be scaled for various designs which require more than two direct-lift engines, or for aircraft designs capable of supersonic performance.



VTOL transports such as this, G-E engineers predict, can be a key solution to traffic problems in today's air terminals. In this design, vertical lift is provided by eight G-E lift fans mounted in the wings and powered by turbojet thrust diverted by valves from the primary engines. Aft-fan power will take over for horizontal cruise.

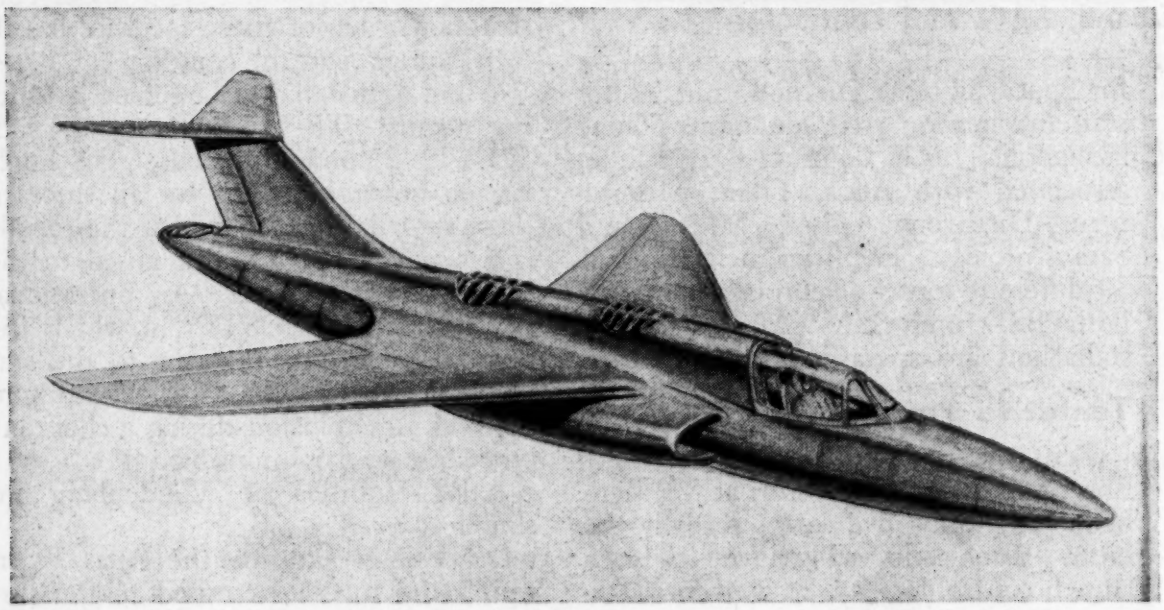
VTOL Transports to Cut Traffic Problem

CINCINNATI, Ohio—Traffic efficiency in today's overcrowded airports will undergo a major improvement when VTOL aircraft for intercity transportation become a reality, predict General Electric engineers.

For example, they said, VTOL designs like the artist's conception shown above may be capable of multiplying traffic volume of existing airports by a factor of ten. Such short-range transports could further supplement airport operations by using "V-ports" located close to downtown areas.

The airframe design shown here, one of several VTOL concepts now under study at General Electric's Flight Propulsion Laboratory Department, incorporates eight G-E lift fans, each driven by wing-mounted turbojets. Diverter valves would control the direction of engine exhaust flow. One of each pair of engines operates only during take-off and landing, each driving a lift fan. The other engine powers a lift fan for vertical take-off and landing, and provides aft-fan turbojet thrust during cruise.

Aircraft of this type are considered feasible for travel between major cities located from 200 to 500 miles apart.



In this artist's concept of a subsonic VTOL system now being studied by General Electric, small direct-lift turbojets mounted in the fuselage and equipped with movable louvered doors, provide lift during take-off and landing operations. Their thrust is supplemented by diverting power from the primary turbojets, which then take over after transition to horizontal flight. Advantage of the system is that it provides optimum engine efficiency during cruise by eliminating need to increase primary turbojet size for additional lift thrust.

High Power-ratio Turbojet Available for VTOL Aircraft

LYNN, Mass.—A lift version of the J85 turbojet engine that has a 10.3 to one thrust-to-weight ratio—the highest of any engine currently available—is now being offered for VTOL applications by General Electric's Small Aircraft Engine Department.

Designated the SJ132, the engine can be ordered now, with delivery subject to a lead time of 12 months.

The SJ132 turbojet, which incorporates existing components of the J85-7 and -5 engines with almost no changes, produces a guaranteed thrust of 3050 pounds. It is especially applicable to VTOL applications in that it can be successfully started and operated in horizontal, vertical, and all intermediate positions, and can provide bleed air up to 10 percent of inlet mass flow for operation of jet reaction VTOL control systems and other purposes.

Considered as a 50-hour auxiliary powerplant, the SJ132 engine can be applied to VTOL techniques using a variety of principles—including direct lift, lift fan, boost engine, or jet pump.

General Electric J85 engines, which have already logged over 33,000 hours, are now accumulating time at an accelerated rate as powerplants for SAC's GAM-72 decoy missile and the ATC's T-38 supersonic trainer.

The G-E SJ133, a more advanced turbojet whose details are still classified, can be available in two years.

NEWS

A report about progress in research and products from the Flight Propulsion Division of the General Electric Company

Turbocopters to Improve Los Angeles & New York Airways Service

General Electric-powered turbocopters having twice the capacity and 50 percent greater speed than their piston predecessors will close the jet-age transportation gap for a growing number of air travelers on the East and West Coasts.

New York Airways' new Boeing-Vertol 107's—powered by twin G-E CT58 gas turbine engines — are designed to carry 25 passengers at a cruising speed of 155 miles an hour. At this speed, free of the traffic congestion below, it will take only six minutes from LaGuardia to Idlewild Airport and seven minutes from Manhattan's Wall Street heliport to Idlewild. Service to Newark and Westchester will be comparably quick.

Los Angeles Airways' G.E.-powered Sikorsky S-61's carry 28 passengers at cruising speeds of 135 miles an hour. The new turbocopters will offer fast, quiet service linking Los Angeles International Airport with such suburbs as San Bernardino, Riverside, Pomona, Ontario, and Anaheim/Disneyland.

For both turbocopters, twin-installations of the 1250-hp, 300-pound General Electric CT58 engine produce 1000 more horsepower than a helicopter reciprocating engine, yet together total less than half its weight.

Convair 880-M Jetliner Enters International Service

SAN DIEGO, Calif. — Convair's new 880-M jetliner is now actively serving points in South America, Europe, Alaska, and the Far East after recently entering service with CAT, VIASA, Swissair, and Alaska Airlines.

During the Swissair delivery flight from New York to Zurich, a distance of 3855 miles, the 880-M completed the longest non-stop distance record ever made by a Convair jet transport.

Japan airlines will soon join CAT with 880-M passenger service in the Far East.

Powered by four General Electric CJ-805-3B engines, the Convair 880-M successfully completed a nine-month flight test program early in August. Increased thrust of the CJ-805's—11,650 pounds each—allows the 880-M a maximum takeoff weight of 192,700 pounds. Maximum cruise speed is 615 miles per hour.

The 880-M is identical in exterior appearance to the 880, except that eight leading edge slots and two leading Krueger flaps are employed to reduce landing and takeoff distances.

The Republic of China's Civil Air Transport (CAT) is using its new 880-M, christened the "Mandarin Jet," on runs from Taipei to Okinawa, Tokyo, Seoul, Manila, Hong Kong, and Bangkok.

Venezuela International Airline (VIASA) flies its new 880-M on routes from Caracas to New York, Miami, New Orleans, Bogota, and Lima.

VIASA's 880-M's will seat 93 passengers—12 in a forward lounge, 32 in a four-across first-class section, and 49 in a five-across coach area. The jet airliners are designed with three galleys, one aft, and two forward, and are fully equipped for over-water flights.

Civil Air Transport's 880-M "Mandarin Jet" now links major points in the Far East.

Alaska Airlines also flies the 880-M on routes between Seattle, Washington; Fairbanks and Anchorage, Alaska. Their Golden Nugget Jet flies the 1565-mile trip from Seattle to Fairbanks in two hours and 50 minutes, considerably faster than any previous schedule.

Japan Air Lines (JAL) will soon have a fleet of five 880-M jets in service on JAL's Southeast Asia routes, and Swissair has announced that two new aircraft will soon serve all Far East points of its international network.

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For free bulletins on the G-E engines and propulsion projects discussed above, just check below and send coupon to General Electric, Section A206-35, Schenectady, New York.

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- ☐ GED-3987A "The CT58 Engine"
- ☐ GED-4666 "The J58 Engine"

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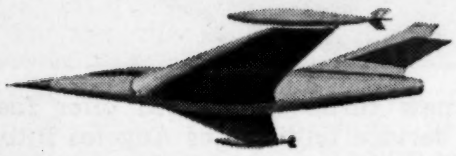
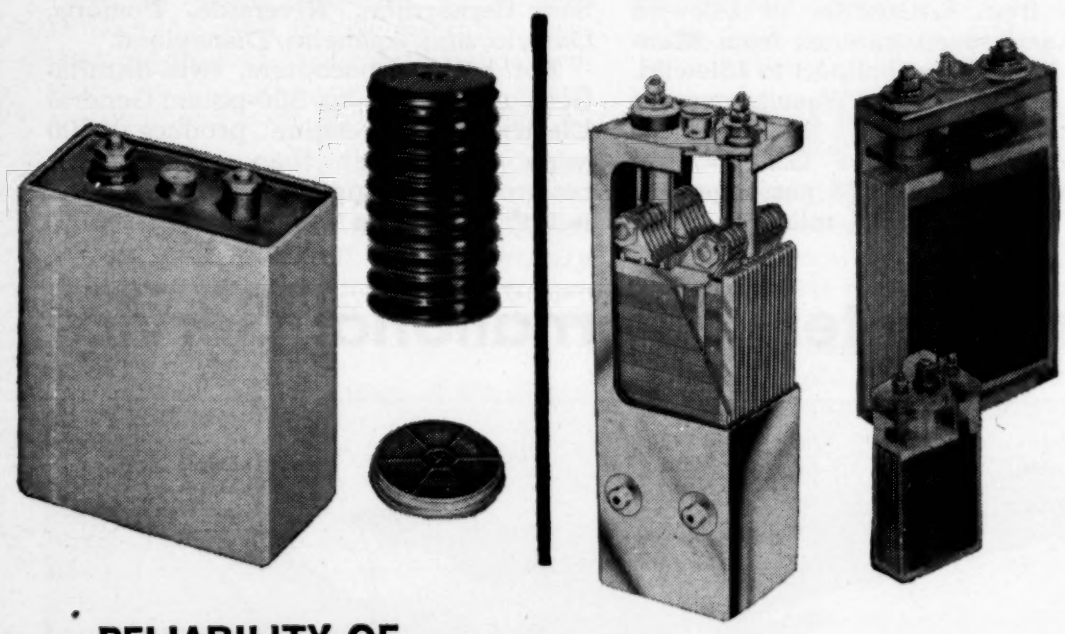
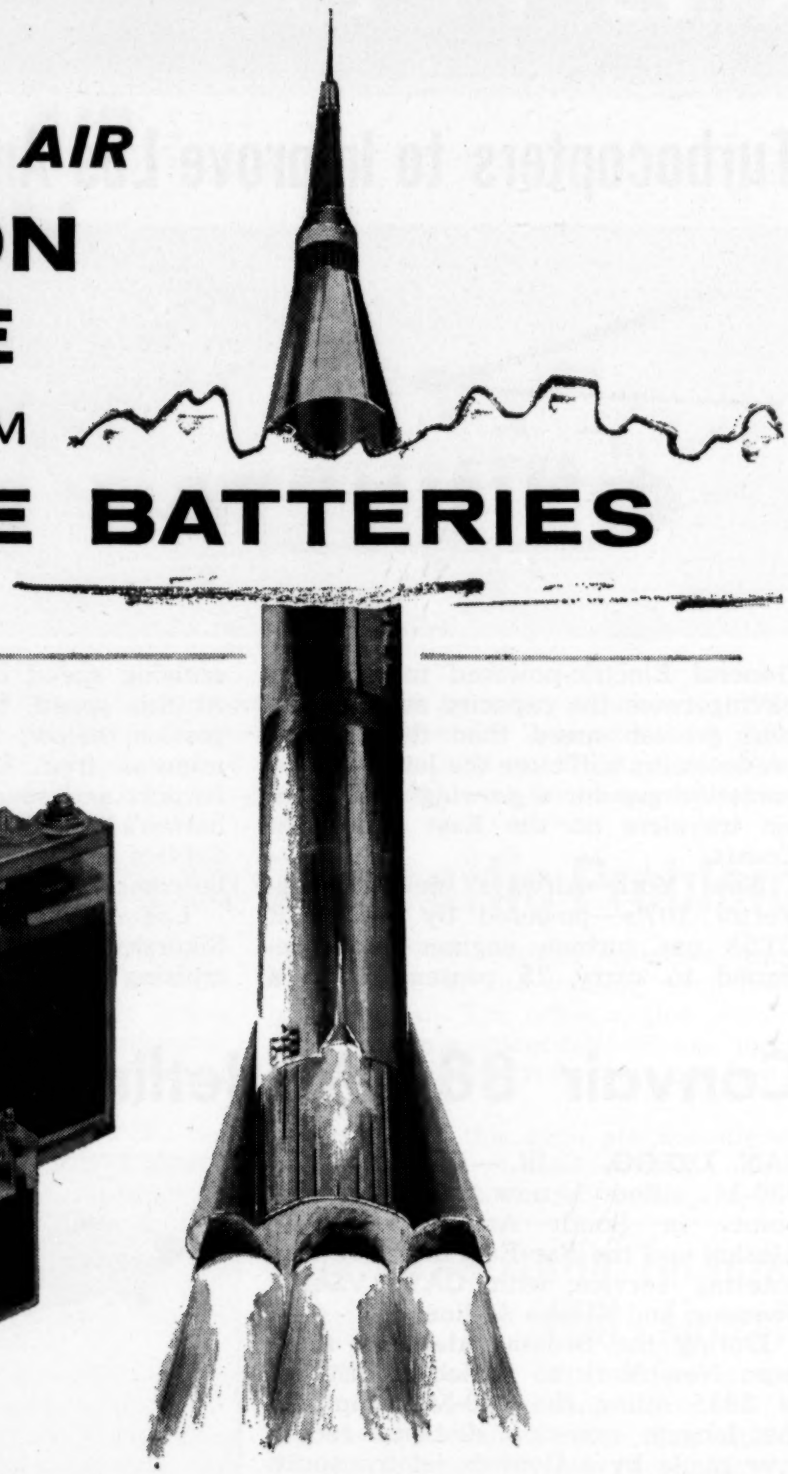
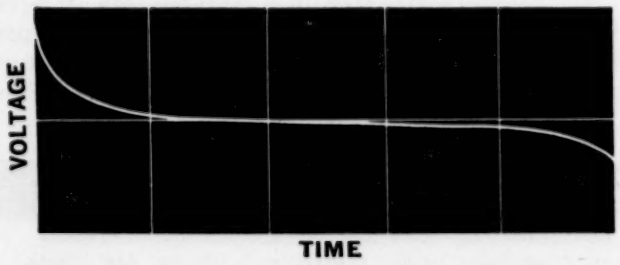
RECHARGEABLE BATTERIES







RELIABILITY OF PERFORMANCE IN ROCKET, MISSILE AND AIRCRAFT CONTROL, GUIDANCE, TELEMETERING, EMERGENCY LIGHTING, ALARMS, SIGNAL EQUIPMENT



One of the main advantages of nickel cadmium batteries, as compared with other systems, is the constant voltage during discharge—even under extremely heavy loads. Shown above is a typical discharge curve.

■ On the ground or in the air, there can be no 'second guess' in specifying a basic power source to operate the control, guidance and telemetering systems for aircraft and space vehicles. Design engineers are specifying NICAD Nickel Cadmium Vented Cells, with assurance, for their extreme reliability and uninterrupted dependability in such critical applications.

NICAD, the foremost nickel cadmium alkaline storage batteries in service today, are widely used by power plants, utilities, hospitals, airports and industry. Under extreme conditions they have provided maximum performance instantly and efficiently. The all-steel construction—virtually indestructible—and non-corrosive electrolyte give NICAD batteries a greater life expectancy than that of any other type of battery.

All these features, coupled with exceptionally long shelf life when on open circuit stand, result in an economical, dependable power source.

Here is round-the-clock readiness for the most critical application. Get the full POWER story from NICAD. Write . . .

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will be available to SAC about the first of next year.

•**OSTF-1,** a below-ground coffin-type launch facility for Atlas E similar to 576C. This is a developmental facility for Category II tests.

• **576C,** one launch position for Atlas E, a semi-hard training coffin below ground having sliding deck flush with the ground. Missile is housed horizontally, elevated to vertical for launch. SAC has been using this facility since last February.

• **576B,** three launch positions for Atlas D—soft, horizontal, above-ground coffins. These have been the sites for Golden Ram testing for Atlas D and will serve for Strategic Air Command's operational readiness training and Category III testing.

• **576A,** three gantry-type launch positions for Atlas D. These facilities will be used for launching the Atlas target missiles for the Nike Zeus exercises, in which a total of 47 missiles is scheduled to be fired, including 18 Atlas Ds, plus Atlas E and F missiles and Titan I missiles.

Operational silo test facilities (OS TF) serve these detail functions:

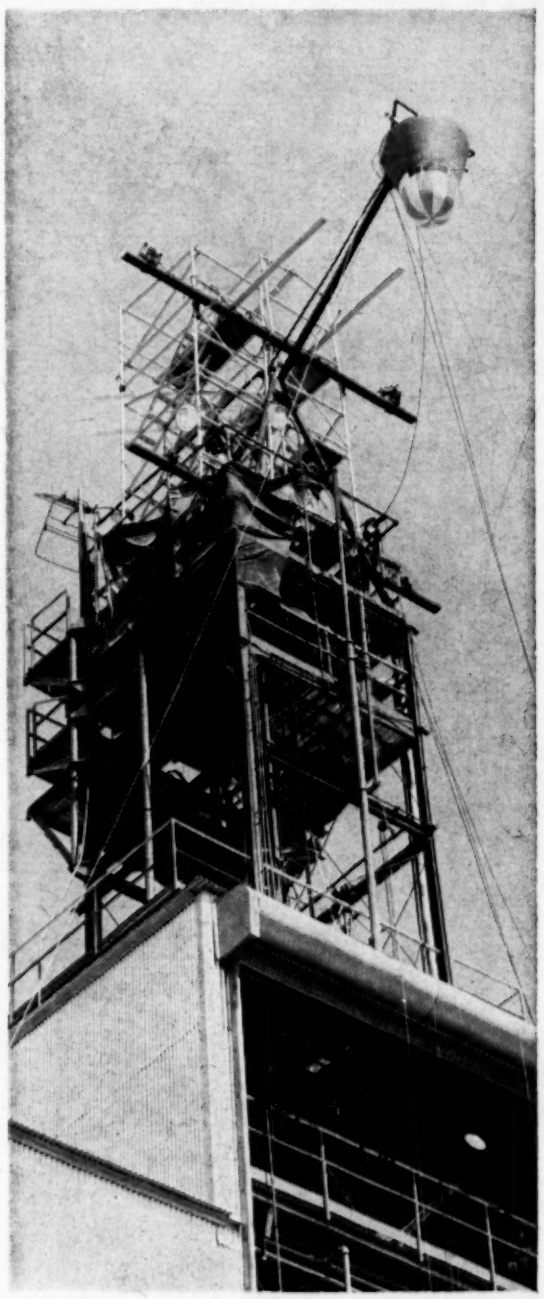
• **Provide experience in installing** and checking the vast complex of equipment, so that field installations at operational sites are simplified and expedited. This broad experience affords a capability for testing the missile in its operational ground environment, including all facility items such as LOX equipment, pneumatics, erection mechanism, hydraulic door opening, and all ground operational equipment (GOE) associated with the missile system, such as launch control, communications, etc.

• **Develop and validate** the operational procedures which are converted into technical manuals by which SAC maintains and operates the systems in the field.

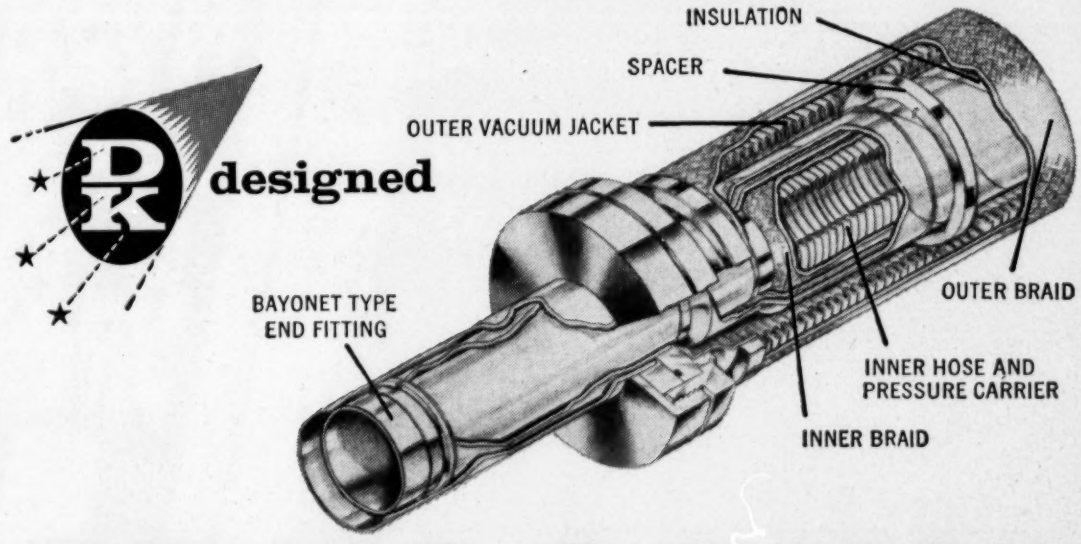
• **Provide for the final Category II** testing, Category III testing, and operational readiness training firings.

OSTFs have substantial instrumentation so that if there is an "abberation" it can be identified and corrected. The training sites are not instrumented to this degree although otherwise are identical to the operational sites.

Commander of the 6565th test wing (Development), Vandenberg AFB, is Col. J. J. Cody, Jr.



RE-ENTRY CAPSULE of an Agena satellite is poised atop a tower at the Lockheed Missiles and Space Division's Santa Cruz, Calif., test facility, preparatory to a drop. The test is designed to exercise the recovery system's parachute operation.



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DK manufactured vacuum jacketed cryogenic lines have exceptionally low heat exchange!

Take a close look at the design and construction of the vacuum jacketed transfer line shown here. You'll quickly see why it answers the problem of transferring costly cryogenic materials most adequately!

DK has combined experience, design capability and advanced manufacturing technique into producing a wide selection of vacuum jacketed transfer lines constructed of flexible metal tubing, rigid tubing and vacuum jacketed gimbals in many combinations. These cryogenic lines are finding diverse applications in Airborne as well as G.S.E. service. Available in standard sizes or in special designs to meet special needs.

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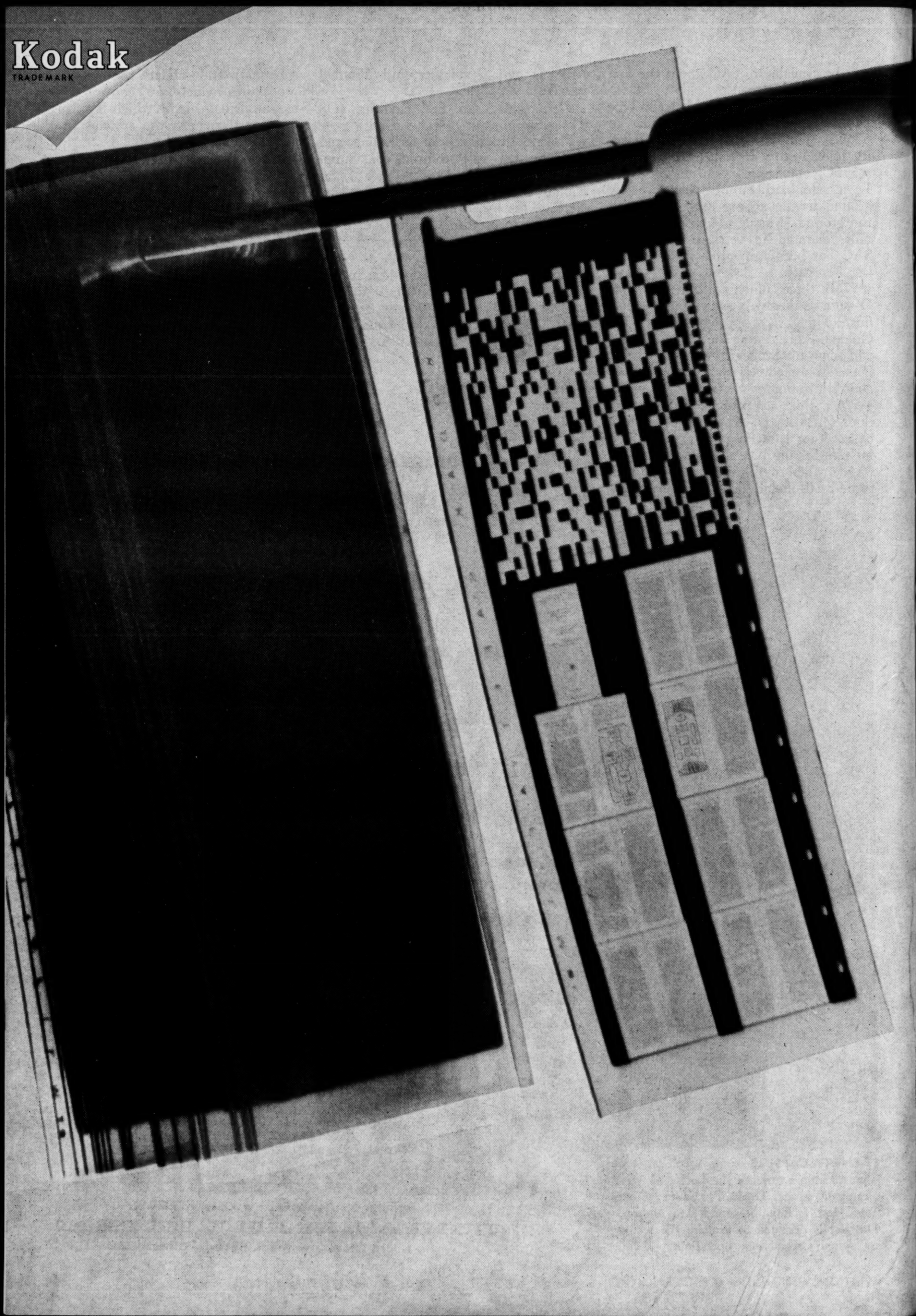

Kodak
TRADEMARK

Kodak's Minicard System...

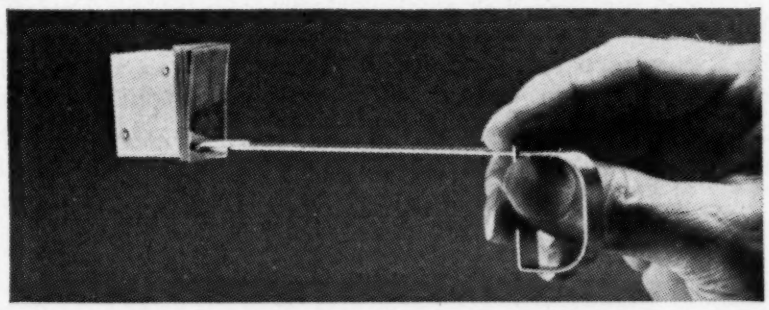
can it replace the stroke of genius?

Never!

It is unspeakable that a piece of hardware—even a piece of hardware priced in seven figures to the left of the decimal point—should replace the genuinely creative human mind.

The sheer gall of so blithely advertising such a price tag need not bowl you over. This nation's bill for research unwittingly repeated bears several more places to the left of the decimal point. (See Document No. 113, 86th Congress, 2nd Session, Senate.*) Since this problem is attracting perceptive, penetrating interest from important quarters and since we are convinced that we have the most feasible and fully engineered answer to it, there is no harm in pointing out publicly the following facts about our Recordak Minicard System:

*For sale in conventional printed form at 70¢ by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. This richly detailed 283-page document comes down to a little "stick" of Minicard chips like this:



The chips are never touched by human hands. The machinery puts them on sticks and shifts them from one stick to another.

1) The Minicard chip of film combines in a single physical entity both a) language the machines can use in classifying to almost any desired depth of detail for quick retrieval and b) microreproduction of the actual document, photographs, manuscripts, article reprints, drawings, or whatever for the human user to examine with his natural-born eyes as soon as the machine has "remembered" it and restored it to size.

2) The small size of these chips permits the machines to search through a vast amount of information at tremendous speed.

3) The Minicard machines further save searching time because the incredible information-packing density of photography and the speed with which it copies information makes it practical for the machinery to duplicate each complete Minicard chip for every pertinent sub-classification. The sub-classification can therefore be made so fine that each contains relatively few Minicard chips for the machinery to zip through.

In short, a Minicard System can occupy legions upon legions of creative minds with very sharply relevant information from the whole store of the recorded past while the stroke of genius is being patiently awaited.

We are also extremely well qualified in experience to discuss information-retrieval problems with those who do not need quite such mighty armament.

PHOTOGRAPHY
OPTICS
ELECTRONICS
MECHANISMS
INFRARED

Information retrieval (on whatever scale of magnitude) represents one problem area in which we are combining our five fields of technology. A booklet entitled "Kodak/A force in being" comprehensively inventories our activities in these fields. Write or phone Advanced Planning Department,

EASTMAN KODAK COMPANY, ***Apparatus and Optical Division, Rochester 4, N.Y.***

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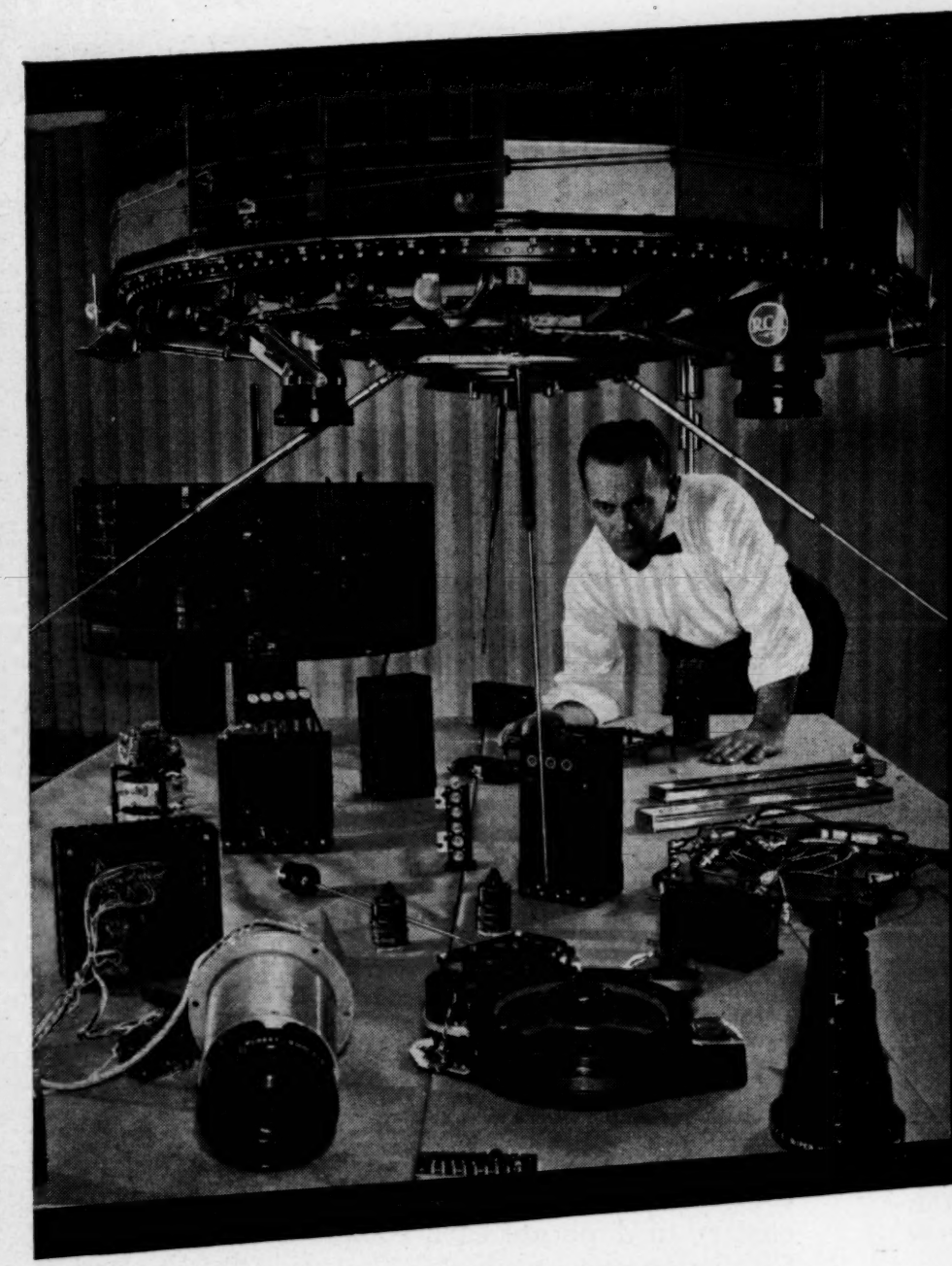

A cross-section of the 40 subsystems incorporating 3500 electronic parts which go into TIROS III are framed by two satellites. All components must be thoroughly tested, precisely integrated and must function perfectly if the satellite is to perform successfully.

NASA's Hurricane spotting TIROS III maintains projects' fine performance record

With the successful launching of TIROS III, meteorologists for the first time will see the total cloud formations and measure the radiative energy balance of hurricanes which plague the eastern coast of North and Central America each year. For TIROS III was launched at this time for precisely this purpose. From information gained from TIROS III, meteorologists may learn much more about the birth and life cycle of tropical storms.

TIROS III DESIGN

Although the spacecraft configuration is essentially the same as the previous two highly reliable TIROS satellites, TIROS III has two wide-angle cameras and the National Aeronautics and Space Administration has placed new omnidirectional IR sensors aboard to measure thermal radiation from the earth and sun.

THIRD OF A FAMOUS FAMILY

TIROS III is the third of a highly successful series of experimental weather satellites which were developed, along with the associated ground equipment, for the NASA, under contract with the Goddard Space Flight Center, by RCA's Space Center. All of them have established "firsts" in the United States' space program.

TIROS II established a longevity record for a complex satellite. Still operating after nearly eight months and over 3300 orbits, TIROS II has transmitted over 34,000 photographs to the ground. Aside from its impressive meteorological achievement, historians may well point to this long-term performance as the first to prove that a satellite system could operate reliably for so many months in a space environment thus proving the feasibility of operational satellites.

TIROS I was the first satellite, carrying advanced television equipment, which sent photographs of the earth's cloud cover to meteorologists. From TIROS I's 23,000 photographs, meteorologists found that satellites could be used for weather observation and analysis. The pictorial information is particularly useful in the two-thirds of the world from which few or no weather observations are now available.

CONNOTATIONS FOR THE FUTURE

The TIROS series has proved beyond a doubt that the peaceful uses of space will benefit all mankind. Six nations participated in the utilization of information from TIROS II and more will take advantage of TIROS III. RCA is also already at work on the camera systems and space power supply for NIMBUS, the next generation of meteorological satellites.

If you are a professional physicist, engineer, or mathematician and interested in participating in such challenging projects and stimulating team efforts, contact the Employment Manager, RCA Astro-Electronics Division, Defense Electronic Products, Princeton, N. J. All qualified applicants are considered regardless of race, creed, color or national origin.

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USAF/BOEING B-52H with Douglas Skybolt test missiles.

Aeronautical Systems

RESCUE

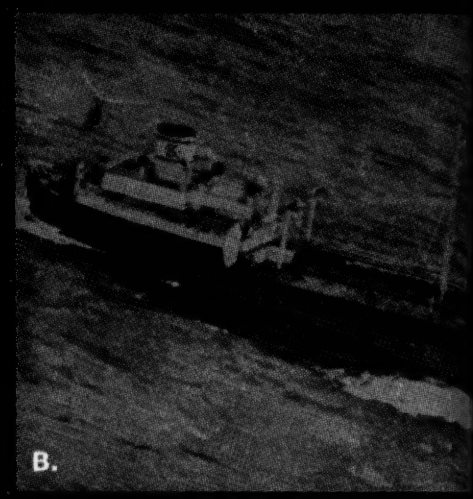
The Kaman HUSKIE was designed to be a rugged, reliable rescue helicopter. It was bred for the boondocks. The number, nature and difficulty of the rescues it has completed since entering operational service prove it was bred right. Rescues involving Kaman helicopters which hit the headlines recently follow below, with on the spot photos to the right.

A. LARSON AFB, WASH.— A Huskie hovering over the burning wreckage of a B-52D used its rotor downwash to keep flames away from the bomber's 128,000 pound fuel load until all 10 crewmen had been safely evacuated. (Air Force Photo)

B. CAPE HATTERAS, VA.— When the tanker Pine Ridge broke up off shore, a Kaman HUK operating from the Valley Forge rescued 9 crew members and returned them safely to its carrier base. (U.S. Coast Guard Photo)

C. RANDOLPH AFB, TEXAS USAF H-43 on standby alert reached the crash scene of a KC-97 tanker and worked with fire fighting crew to prevent flames from spreading to 4,000 gals. of spilled fuel, saving the aircraft. (San Antonio Field Photo)

THE KAMAN AIRCRAFT CORP., BLOOMFIELD, CONN.



In national defense
KAMAN is a part of the rescue pla

This demonstration photo became a reality at PLATTSBURG, N.Y., when one of the crewmen who bailed out of a crippled B-52 was injured when landing in an isolated area of 100 foot trees. The crew of a Huskie saved his life by hovering over the spot and lowering a medic to give first aid until rescuers on foot reached the scene.

USAF Charting Future Spacecraft Needs

Aeronautical Systems Division manages, programs life cycle of military aircraft, aerodynamic missiles.

Wright-Patterson AFB, Ohio—Aeronautical Systems Division fights its battles in the narrow corridor of flight, hemmed in on one side by air too thin to sustain lift and on the other side by heat too great for man or machine.

The job of the division is to move out through those boundaries by every trick, every stratagem, every technological development in the books, and, after exhausting those, to write new books.

These new books, written by the division's dedicated personnel, chart the flight boundaries of tomorrow's aerospace craft. And that, essentially, is the formal mission of Aeronautical Systems Division. It plans, programs and manages the life cycle of military aircraft, aerodynamic missiles or those associated with aircraft, manned aerospace craft and their supporting systems. Parallel with this formidable task it has another one, equally demanding: to advance the technology for future Air Force systems exploitation.

Commanded by Maj. Gen. Waymond A. Davis, ASD is a merger of two major operations, once separated into different USAF commands. Wright Air Development Division, of the former Air Research and Development Command, was established in 1959 from the earlier Wright Air Development Center. The previous year, Air Materiel Command had established the Aeronautical Systems Center.

Between them, both organizations combined the research, development, production and procurement of a weapons system right through its life cycle and up to the point of operational takeover by some using command.

The reorganization of ARDC and AMC into the Systems Command and Logistics Command merged the AMC's Center with ARDC's Division, and set them under Gen. Davis.

Emphasizing the two-headed role of the Division, Gen. Davis has two special assistants: Dr. John E. Keto, for engineering and scientific matters, and Louis R. Koepnick, for procurement and production.

Thus the logical arrangement of the entire time cycle of a military system comes directly under a single command and a single commander. This concept of singleness is a thread that runs through the fabric of ASD.

Deputy for Technology

If there is such a thing as a starting point for a system, this is where it would be found. In the technology directorates, headed by Col. A. L. Wallace, Jr., Deputy for Technology, are combined state-of-the-art research, applied research and the familiar laboratories that once were the major portion of activity at this base.

Wallace's directorates have a simply defined mission: Look ahead. In the more formal language of the defined mission, the Deputy for Technology is charged with identifying and defining future systems, compressing the system development cycle, incorporating latest technologies into systems and conducting research oriented toward systems or toward a high future payoff.

More than 1,200 scientists and engineers out of a total of 1,800 personnel report to the D/T, including a group of more than 250 USAF officers. Recruiting for this area, like recruiting for any technical job, does not produce all the desired results because of the intense competition and the high standards set by ASD for its specialized personnel. But because of extensive contact with universities—which hold a large portion of the D/T contracts—and the broad spectrum of technical interest, this Deputy is able to hold its own in getting and keeping technical personnel.

About $185 million is spent annually, with a large percentage of that money going out of D/T to universities, research and non-profit institutes. Of the outside contracts, 99% of them, says Wallace, are cost-plus-fixed-fee type. Monitoring these contracts is done with an iron hand; there is no "slush fund" available to take care of overruns. Current overrun—in spite of everything—is approximately 4% of the total contract value.

The physical plant and equipment of the D/T, which includes the former Aircraft, Equipment, and Propeller Laboratories, totals 34 buildings with an enclosed floor space of 721,000 sq. ft. Value of the plant is about $80 million.

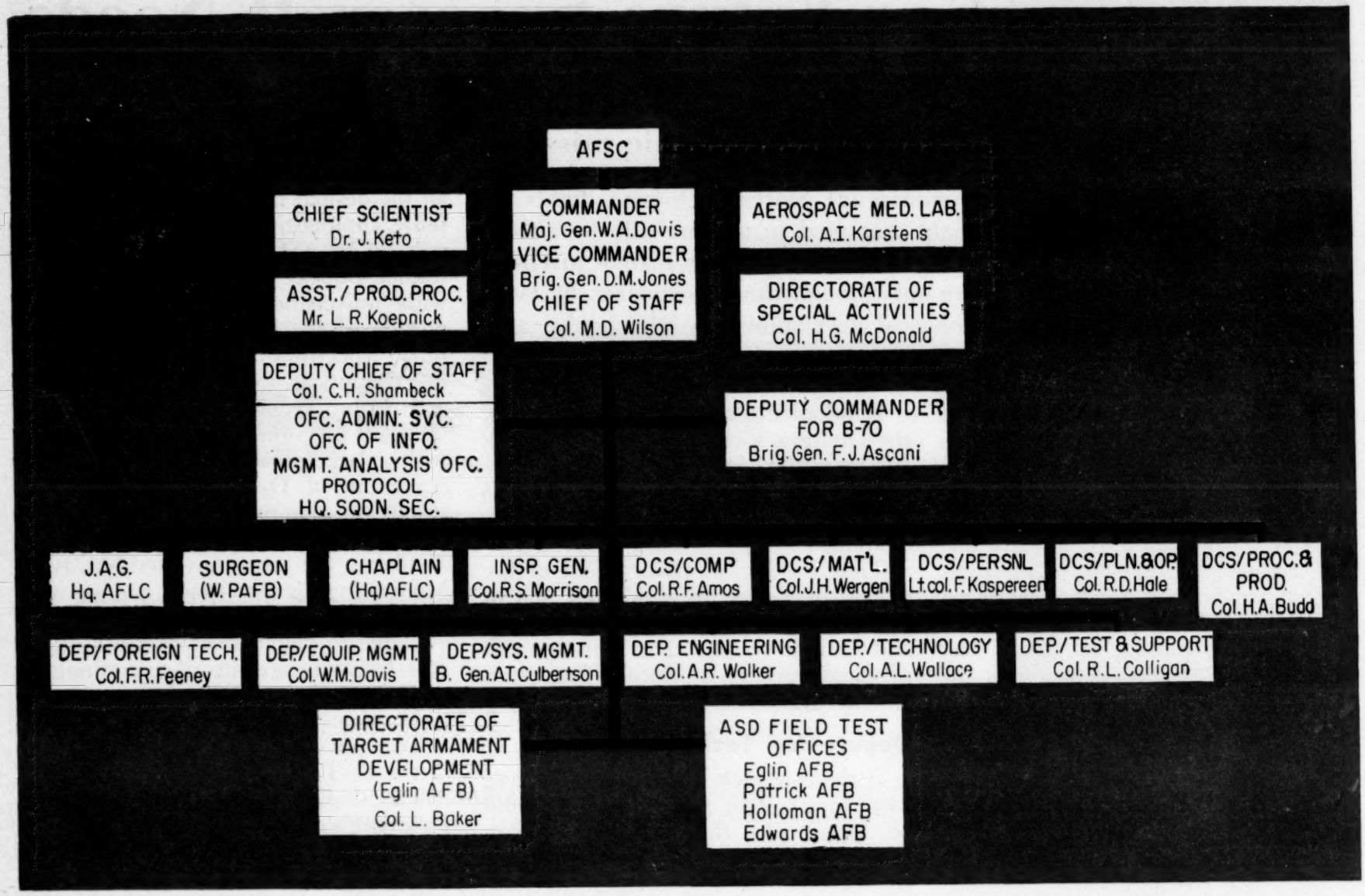
Development Role

Studies are generally the first milestone of a development cycle; here in the D/T the first facts are assembled, the first studies made, the first decisions to tackle development are taken. Starting with study reports, passing through applied research programs and finally producing a system development plan, the D/T shepherds a new system through its gestation period.

But more than a development plan can come along with the new system from D/T. Along the way, new techniques of fabrication may have been evolved, or some new material that makes the difference between possibility and probability. Feasibility models or breadboard samples may have been built to make sure that most of the pitfalls have been charted. And, if in the follow-on work someone needs the services of a technical specialist, the chances are good that support will come from the D/T.

Development responsibility for a new system leaves the D/T upon approval of the development plan, and becomes the problem of the Deputies for Systems Management and Systems Engineering. But there is one more responsibility of the D/T: a reappraisal of the system by the Directorate of Advanced Systems Planning (DASP) to check that the latest technical knowl-

Maj. Gen. Waymond A. Davis, Commander, Aeronautical Systems Division, AFSC . . . born Yantis, Texas, 1914 . . . graduated Texas Technological College with BS in Mechanical Engineering 1936 . . . received wings 1937 . . . commander, 5th Photo Reconnaissance Group and operational engineering officer, 12th Air Force, 1943 to 1945 . . . duty with AMC in aircraft procurement 1945 to 1953 . . . industrial College of Armed Forces, 1953 to 1954 . . . deputy director, Procurement and Production, Hqs. USAF 1954 to Director, 1955 . . . deputy director Weapon System, AMC, Wright-Patterson AFB, 1959 to director of Procurement and Production, Hqs. AMC.



AERONAUTICAL SYSTEMS DIVISION ORGANIZATION CHART

edge has been fed into the systems proposal.

Systems studies and applied research were integrated in this organization to make sure that they would both profit from the cross-feeding that is the major sustenance of technology.

From the advanced systems studies of the DASP come defined needs for applied research, and these needs act as objectives for one or more of the laboratories of the three Directorates: Materials and Processes, Aeromechanics and Avionics.

Running parallel to these specific requirements for research effort is the applied research done in the laboratories and aimed at no specific system. From these programs come the clues that lead toward future systems, clues that are the lifeblood of the DASP in its studies for tomorrow.

Basically then, the Deputy for Technology is built on research in one form or another. It uses this research in the formulation of development plans; it does this research in its laboratories. But it also monitors areas of research for the entire Air Force in a management concept new to USAF and referred to as TAM (Technical Area Management).

All of USAF's applied research is categorized into 28 major technical areas. Each of these areas of interest—examples are propulsion, flight mechanics and reconnaissance—is monitored by a senior scientist who controls the money, priorities and the extent of the program. Eleven of these technical areas are assigned to TAMs (Technical Area Managers) within the D/T. The other 17 TAMs are somewhere else in the Systems Command.

Supporting Effort

The Deputy for Technology has an interest in all the Air Force applied research programs and may have supporting effort to perform in one or more of the areas not directly managed by a TAM in the D/T. For this job there are TACs (Technical Area Coordinators) handling the support job in areas not directly under the D/T.

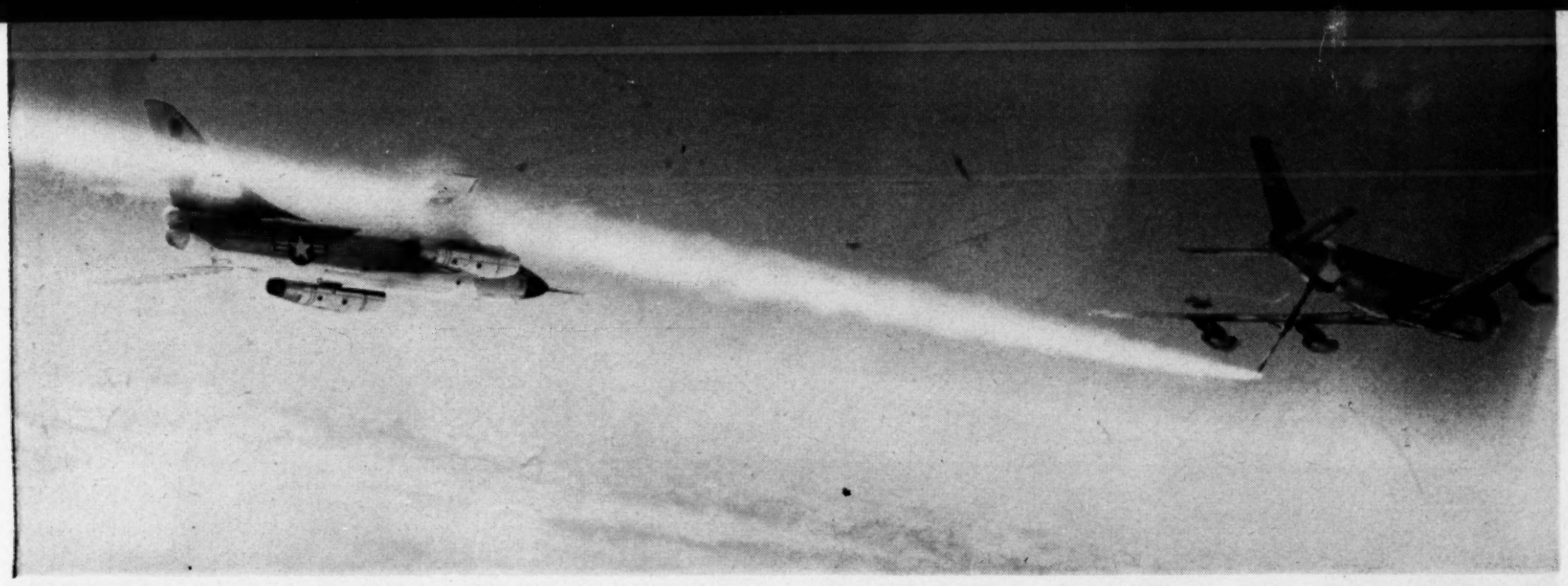
To keep the TAMs from working in a vacuum, there is a final alphabetized group referred to as POCs (Planning Objective Coordinators). Each one of these scientists is responsible for a planning objective, and is the driving force behind the applied research effort done for his objective.

Within the D/T, systems studies now are being pointed towards operational dates from the mid-sixties to the early seventies, and increasingly towards a space environment. They include:

- **Manned orbital vehicles** for reconnaissance and surveillance. These studies, high on a national priority list, are aimed at orbit times from a few hours to many weeks, with re-entry and return to base capability a must.
- **Aerospace Plane,** a hydrogen air-breather with capability of flying into an orbit after takeoff from conventional runways.
- **Strategic satellite strike system,** for retaliation from space.
- **Recoverable booster** for space operations. This type of system will be necessary as boosters become more expensive and less expendable.
- **Supersonic transport** for Mach 3 logistics.
- **Military test space station,** to provide a true space environment with zero gravity, solar radiation and perfect vacuum to check out the equipment and components of future space systems.

Typical applied research areas being investigated by the Deputy for Technology include:

- **Gas turbine technology,** aimed at the development of lightweight, high-thrust engines for VTOL aircraft.
- **Non-metallic materials** to reflect or absorb radiation as desired. Applications currently include uses on three orbiting vehicles: Transit, Discoverer and Samos.
- **Non-metallic materials** in ballistic missiles. Starting at the ablative plastic nose cone and going right down



BOEING KC-135 is flying ice-wagon, spraying water from metering head at end of refueling boom. Douglas B-66 is flying with right wing panel submerged in water spray to produce icing conditions.

through the missile to a reinforced-plastic skirt, non-metallic materials are finding increased uses for specific tasks where the properties show real payoffs.

• **Bionics,** one example of the high future payoff research area. How can a Cecropia moth, using one-inch long antennas to smell with, be able to identify other moths as far away as three miles? How does the bat's supersonic sonar work? The answer to these questions may increase future systems capabilities.

• **Molectronics,** attempts to control the crystal structure of semiconductor material, is another area where the D/T is establishing a broad program.

• **Inflatable structures,** so that large shapes may be put in orbit in a volumetrically small package and then expanded once in orbit. Such structures could be made rigid by using foam-in-place plastics after inflation.

Finally, one example of a technical area program should furnish a deeper insight into the way the Deputy for Technology functions in these areas. In the Reconnaissance Laboratory, a major area of interest is photo-reconnaissance technology. Simply listing the subjects involved, rather than the specific investigations in each subject field, shows the extent of the work:

• **Advanced photo experiments** from parachutes and missiles; environmental effects; auxiliary data recording; positioning and locating the reconnaissance vehicle; atmospheric effects.

• **Photographic windows;** camera mechanisms and controls; photo-sensitive materials; image intensifiers; sensor attitude control; stabilization; image motion detection and compensation; lenses; photo processing.

Systems Management

Next major milestone in the life of a military weapon system is its assignment to the Deputy for Systems Management. The organizations grouped under this Deputy, headed by Brig. Gen. A. T. Culbertson, include System Program Offices (SPO) and Project Offices (PO) for new and evolving aircraft and missiles.

One of these programs—the North American B-70, a Mach 3 bomber system—has sufficient priority and importance to the USAF to warrant a special office under Brig. Gen. Fred J. Ascani, who also carries the title of Deputy for the B-70.

There is a total of about 50 different programs grouped under the D/SM, ranging from the TM-76, which started life as the Martin Matador air-breathing missile about 15 years ago, to the Dyna-Soar, a prototype research vehicle for studies of space operations.

The primary job of the SPOs and POs is management: planning, directing, controlling, and coordinating along the lines of the requirements for the program. About 1,050 people are involved in the various offices, and they jointly manage contracts totaling about $2 billion.

SPO Evolution

The SPOs are not a new organizational concept; they evolved directly from the Weapons System Project Offices (WSPOs) of the previous reorganization. The Deputy emphasizes that the new organization of Systems Command does not alter the relationship between the SPOs and industry.

The recurring concept of SPO management, regardless of the state of the program itself, is one of singleness: one program, one manager, one control. The program is packaged from planning to operations; there is a single manager responsible for the entire program; and there is one point at which industry, government agencies, other governments, and the USAF itself can contact the program. That single point is the SPO.

A typical SPO includes a control office to function as planners, fiscal managers, operations specialists and evaluators. There will be representatives from the ultimate using command and from training command so that their specialized needs will not be overlooked, and so that they will be able to integrate the program into their own operations with a minimum of trouble. Air Force Logistics Command will have an office; so will systems engineering, test, production and procurement.

Major Task

First major job of the SPO in moving a system through its cycle is definition of the program. This includes consideration of other possible ways of meeting the specified requirement (modification of existing systems, for example), cost effectiveness, technical aspects, procurement problems and every conceivable factor that would affect the final system. Out of this comes the systems package plan.

This leads to implementation of the program through directives, the contract and the specifications. But it also asks questions. Should the job be done with a single prime contractor or associated contractors? Are we pushing the state of the art too hard, or too far? Should we make or buy? Does the contractor really need those two new buildings or can he subcontract for less total cost and maintain effectiveness?

Throughout the life of the program, continuing analyses keep the system dynamic. Applications of advanced management techniques, such as the Navy-developed PERT (Program Evaluation and Reporting Technique), keep watch on schedules, costs and manpower allotments. Reliability is continually monitored, through research, development and production of the system.

Demonstration and proof of the system, the next phase of the SPO task, give the first clues to systems effectiveness. Initial development testing done by the manufacturer is followed by detailed evaluation done where the Air Force has specialized capability or experience.

Finally, production and delivery of the system to operational inventories is the last continuing responsibility of

30 advanced SuperJets joining TWA fleet!

TWA is now expanding its huge jet fleet with 30 of the newest and most advanced jets in the air. In every way, these are SuperJets plus: They have power plus: new high-thrust turbofan engines for shorter takeoffs, faster climb. Speed plus: to 625 miles an hour. Range plus: increased fuel reserves. Comfort plus: they fly smoother, faster and higher, far above the weather. Dependability plus: added on-time capability. These 30 additional SuperJets will give TWA the world's finest fleet of 4-engine jets and bring you the world's finest jet service.

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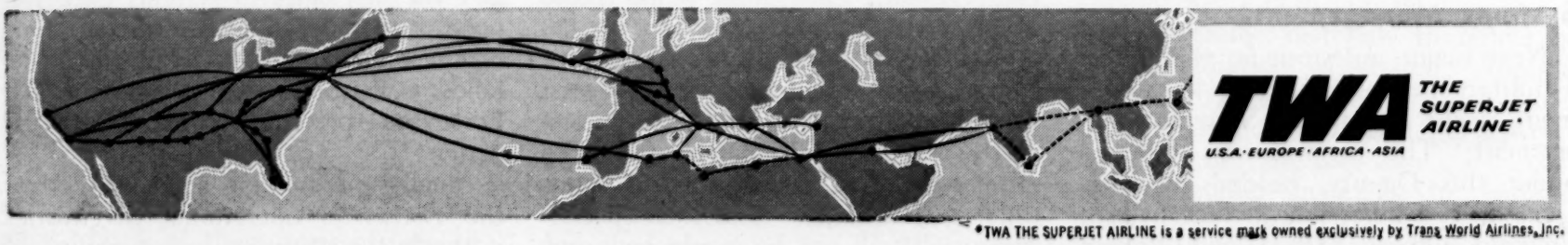

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the SPO. Value engineering and other techniques of quality, production and cost control are used by the office in continual monitoring of the delivered systems.

All of these point to the final goal of the Deputy for Systems Management: the acquisition of superior systems at the earliest feasible time for the lowest reasonable cost.

Deputy for Engineering

Col. A. R. Walker, Deputy for Engineering, gets into the nuts-and-bolts problems of systems in direct engineering work, or in supporting roles. The D/E furnishes engineering support to systems management, does systems evaluations, and finally acts as integrator of new systems so that matching of all components and subsystems produces a workable, operational-ready weapon.

Approximately 1,500 technical personnel comprise the D/E; they are aided by about 350 clerical and support personnel. Someone has said that the aggregate experience of this group is synonymous with the history of manned flight development; this may be dramatic, but it's one way of pointing out the wide capabilities of the D/E.

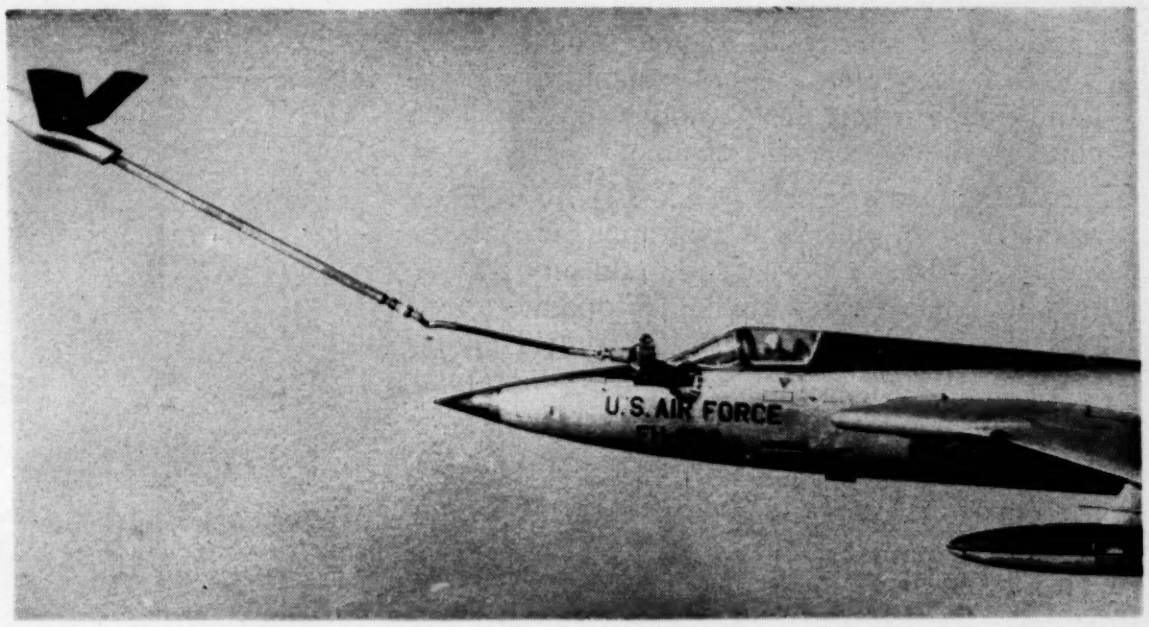
Organizationally, there are four major groupings within the D/E:

- **System Program Engineering Offices,** one-system organizations that for all practical purposes work for the System Program Directors. In these offices lies the responsibility for hardware and engineering of the specific system; however, the engineering decisions may have to be modified or even overruled by one of the management deputies for other reasons.
- **Two General Directorates.** One of these is the Directorate of Strategic and Tactical Systems Engineering, and the other is the Directorate of Defense and Transport Systems Engineering. Functionally organized, these offices are responsible for more than one system each.
- **Two Special Directorates,** one for Aerospace Ground Equipment Engineering and the other for Operational Support Engineering. These units generally provide engineering support for their management counterparts in the Deputy for Equipment Management.
- **Two Special Directorates,** one for Engineering Standards and the other for Systems Dynamic Analysis.

Two dissimilar but related problems make good examples of the kind of work done in D/E: Wing tank corrosion in the Boeing B-52 and Boeing KC-135 fleets, and the wind modification program for the B-52G and B-52H models.

About 10 to 15% of the B-52/KC-135 fleet has shown sufficient integral fuel tank corrosion to demand rework

MODIFIED FLYING boom system, developed for converting Boeing KC-135s to probe-and-drogue tanker configuration for Tactical Air Command use, was tested by pilots of Aeronautical Systems Division's Deputy for Test and Support.



to maintain structural strength. The corrosion was found during High Stress 2, a second series of structural modifications done at the AMA level as a result of cyclic tests done on a representative fleet article.

Corrosion Mechanism

The mechanism of the corrosion is not completely understood, but it involves some combination of water, salt, iron and bacteria. First B-52s to show the effects were from Ramey AFB in Puerto Rico, where a marine tropical environment combined with a fuel deficiency—a naphtha strain which attracted water and held it in an emulsion—started the corrosion.

Several approaches are being used to improve the problem. First, changes in fuel procurement specifications, coupled with a new emphasis on handling storage and loading procedures, are expected to eliminate much of the source of the contamination. Second, a new epoxy with a polysulfide base has been specified as top coating for the wing tanks, in the hope that it will be less appetizing for the bacteria than the Buna-N now being used. Third, some new polyurethane coatings are being developed and will commence service tests this month.

This problem, incidentally, is not unique in USAF. Commercial operators using the Lockheed Electra have reported similar problems and have been exchanging ideas and experience with the D/E in the hope of making a solid attack on the problem.

During cyclic tests of a B-52, cracks developed in the wing structure and gave clear evidence that the original wing design would not stand up to the fatigue damage done during current operational use. It should be pointed out that the airplane design met original requirements: when requirements are

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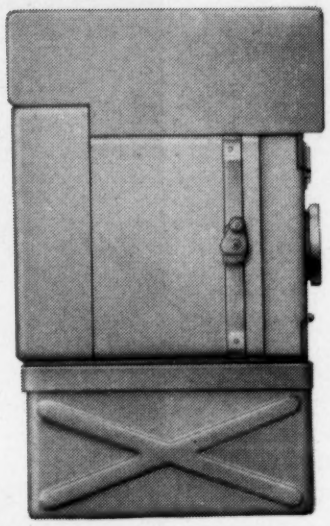

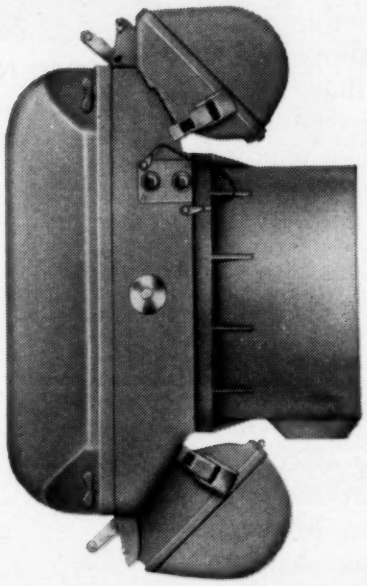

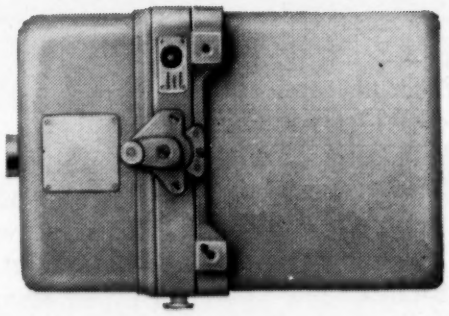

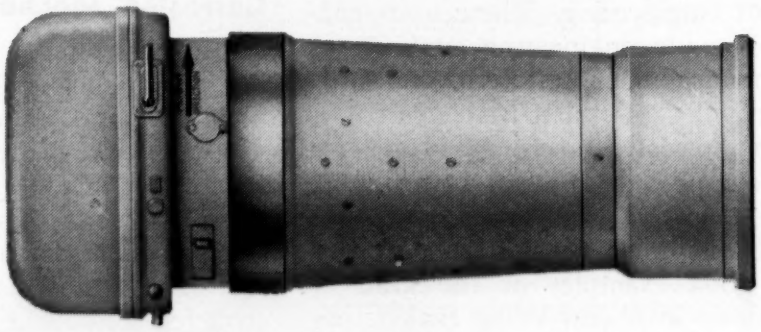

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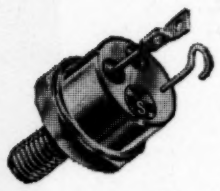

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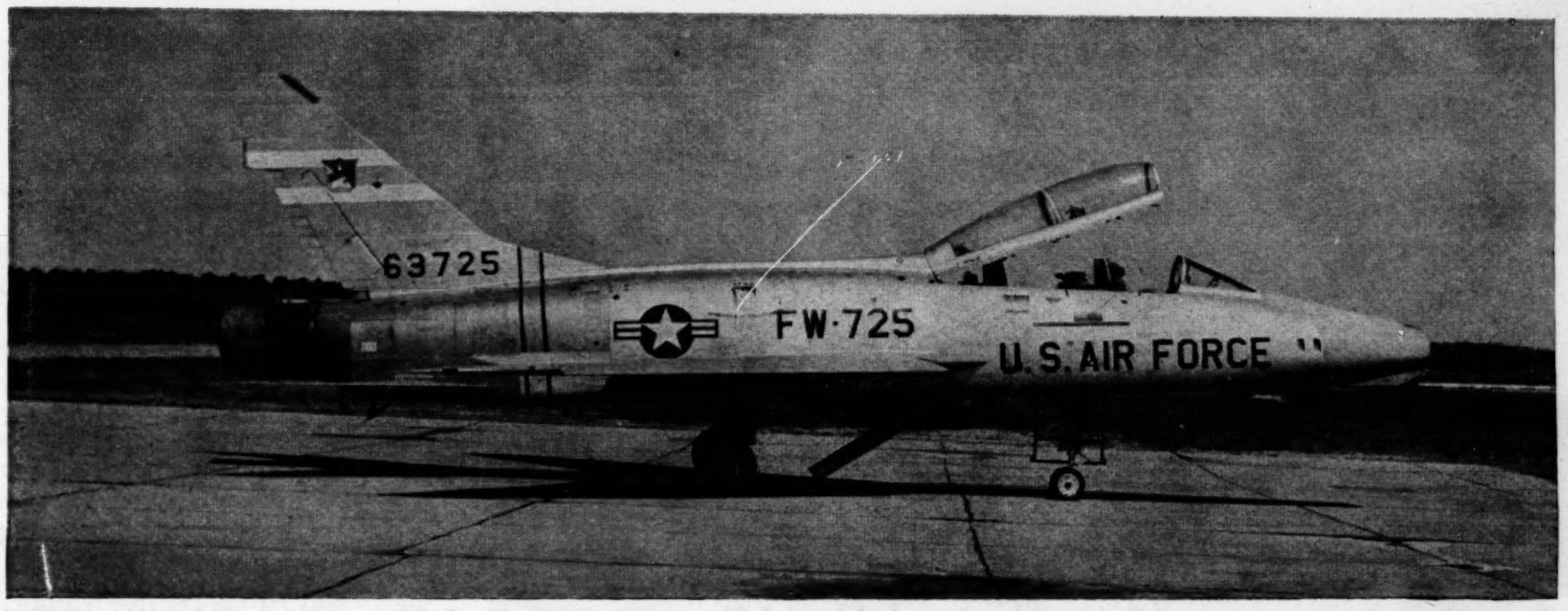

NORTH AMERICAN F-100F, modified with thrust reverser, added speed brake area and laminar flow control on the flaps. The modified North American plane is currently being utilized to simulate high-sink-rate approaches and landings.

changed drastically by a complete switch in operational use, any airplane is bound to have trouble. And there was trouble; a B-52 was lost during the "new" use of the bomber.

The Directorate of Strategic and Tactical Systems Engineering set up a task force of about 20 specialists in structures, flight loads, flight controls, propulsion and aerodynamics to tackle its phase of the work. Boeing organized a group to start work on a series of parallel approaches to fixes, each of which went further into the problem. The first and easiest involved skin gage changes; the last and toughest was a complete wing redesign.

By February this year, Boeing was ready to propose six programs for the Directorate to consider. In March there was a review at Boeing and the Directorate bought the fix calling for complete modification of the wing box. This involved new materials, clean-up of detail designs, increased skin stiffness and the reduction of stress levels in critical areas.

By now, all engineering drawings for the fix should have final approval, and scheduled retrofitting of the new wings should begin next June. The entire fleet of B-52G and B-52H aircraft will be retrofitted with the modified wing box at the first opportunity.

Laminar Flow Control

Typical program in the Directorate of Defense and Transport Systems Engineering is the concept of a laminar flow control program system. Currently active at Northrop, where a pair of Douglas B-66 aircraft will be extensively modified for the program, LFC is the product of long and patient years of waiting to get something done in this line.

Credit for the idea cannot be placed anywhere specifically; it has stemmed from a long line of development work in boundary-layer control that started at least 25 years ago.

Certainly a major portion of the background work leading to this specific system can be credited to Northrop, where contracts for study of the problem have been under way for the past several years.

One interesting angle on this program is that the Directorate engineers determined that wing-mounted engines would generate enough energy in the form of noise to affect seriously the laminar flow over the wing. For this reason, the engines on the redesignated NB-66 test aircraft will be mounted aft.

Portable Unit

The Directorate of Aerospace Ground Equipment Engineering says that its work can be typified by the experience of obtaining a truly portable noise suppressor for jet aircraft. The need for such a device is obvious; but none of the off-the-shelf units tested was satisfactory.

So the D/AGEE set up a development contract with Kittell-Lacy Corp., El Monte, Calif., and this produced an acceptable silencer. In fact, says the Directorate, "This is the only sound suppressor developed to date which has demonstrated the capability of satisfactorily reducing the noise level in the far-field to meet Air Force requirements."

Final check under the aegis of ASD is the job of the Deputy for Test and Support, headed by Col. R. L. Colligan, Jr. Colligan's air force, which employs 53 professional pilots and about 2,200 total personnel, gets the job of wringing out subsystems, components and complete systems, plus tackling a wide variety of other jobs from the ground up towards—and eventually into—space.

Working in a volume of restricted airspace about 45 by 115 mi. in size and located to the southeast of Dayton, Colligan's crews have flown more than 5,000 zero-g maneuvers for aeromedical test support, refueled Republic F-105s checking a new system for Tactical Air Command, sprayed water on fighters to prove out their de-icing systems. Projects assigned to the D/T&S have included:

- **"Rough Rider,"** a series of penetrations of thunderstorms to find out what happens. "Plenty does," said Colligan, pointing to pictures of hammered duct inlets and peeled rivet heads on the leading edges of a Convair F-106. "Maj. Knight flew that bird into the storm, hit it at about Mach 1.6 and decelerated to Mach 1.35 in less time than I can say it," Colligan said. His outfit also flew a Douglas B-66 in subsonic penetrations of the storm. Data from the penetrations gets fed back to Air Defense Command, among others, which wants to know what happens physically to airplanes when they have to get up and go regardless of the weather conditions.
- **Zero-gravity maneuvers.** More than 3,600 zero-g maneuvers have been flown in a Convair C-131, and about 1,600 in an internally modified KC-135. Time periods of the maneuver vary from 15 sec. for the Convair to almost one minute for the KC-135.
- **High-sink-rate approaches.** The kind of problems that a Dyna-Soar vehicle might pose in approach and landings are being simulated here by a modified F-100F. The afterburner has been replaced by a thrust reverser; the belly speed brake has been increased in size. Laminar flow control is used on the flaps to maintain a high angle of attack without stalling. Colligan said that the pilot of this test aircraft can be at 20,000 ft. about eleven miles off the end of the runway, and by using the reverser, speed brake and LFC, he can land "on the numbers." These fig-

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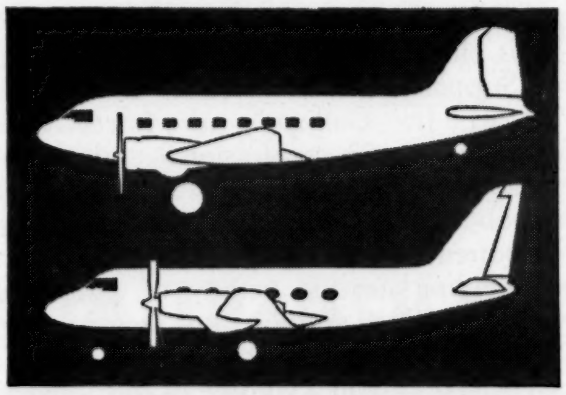
In the illustration, right, you see two airplane silhouettes: the first, a DC-3; the second, a Grumman Gulfstream. Note how closely they coincide in size. The Gulfstream is the modern pressurized, high performance replacement for the DC-3 and other older transports; equivalent to the DC-3 as a work horse transport—and costing even less to operate—the Grumman Gulfstream is a new airplane proved in service by over 60 world-wide corporations and the Federal Aviation Agency. Modernization of our country's airlift capacity for limited or brush fire warfare can be accelerated by the Grumman Gulfstream. And it's available *now.*

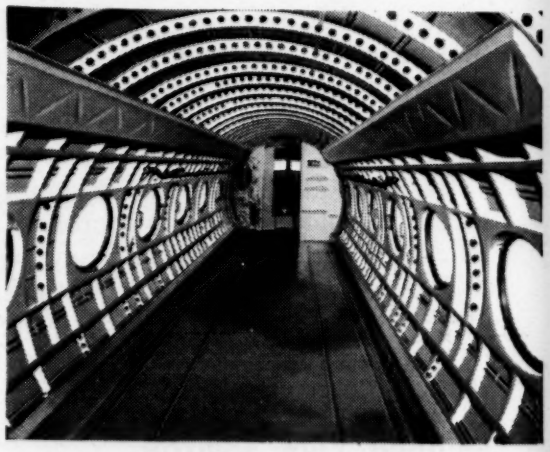


Gulfstream compared to DC-3

Facilities inspection

Here are the Gulfstream's capabilities: For military application, it will carry up to 24 passengers and has a transcontinental range against 50-knot head winds. It needs only 3,000 feet of runway, enabling personnel to use fields close to their destinations. It is completely independent of ground handling facilities. With its pressurization system (up to 30,000 feet), it flies above weather and traffic at a cruising speed of 350 mph and is powered by proven turboprop Rolls-Royce engines. An active development program is in progress at Grumman for the installation of the General Electric T64 turboprop engine as an alternate source of power.

Air evacuation



Multipurpose Gulfstream cabin

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ures correspond to a glide-path slope of about 35%.

• **TAC refueler.** Tactical Air Command has been kept from using KC-135 jet tankers because of the boom system in the refueling aircraft. TAC fighters use probe-and-drogue systems, refuel now from KB-50s. But a modified boom system, featuring a drogue attached at the end of the boom, has been developed and one of the D/T&S flight-test programs involved air-to-air hookups with the new system in a KC-135.

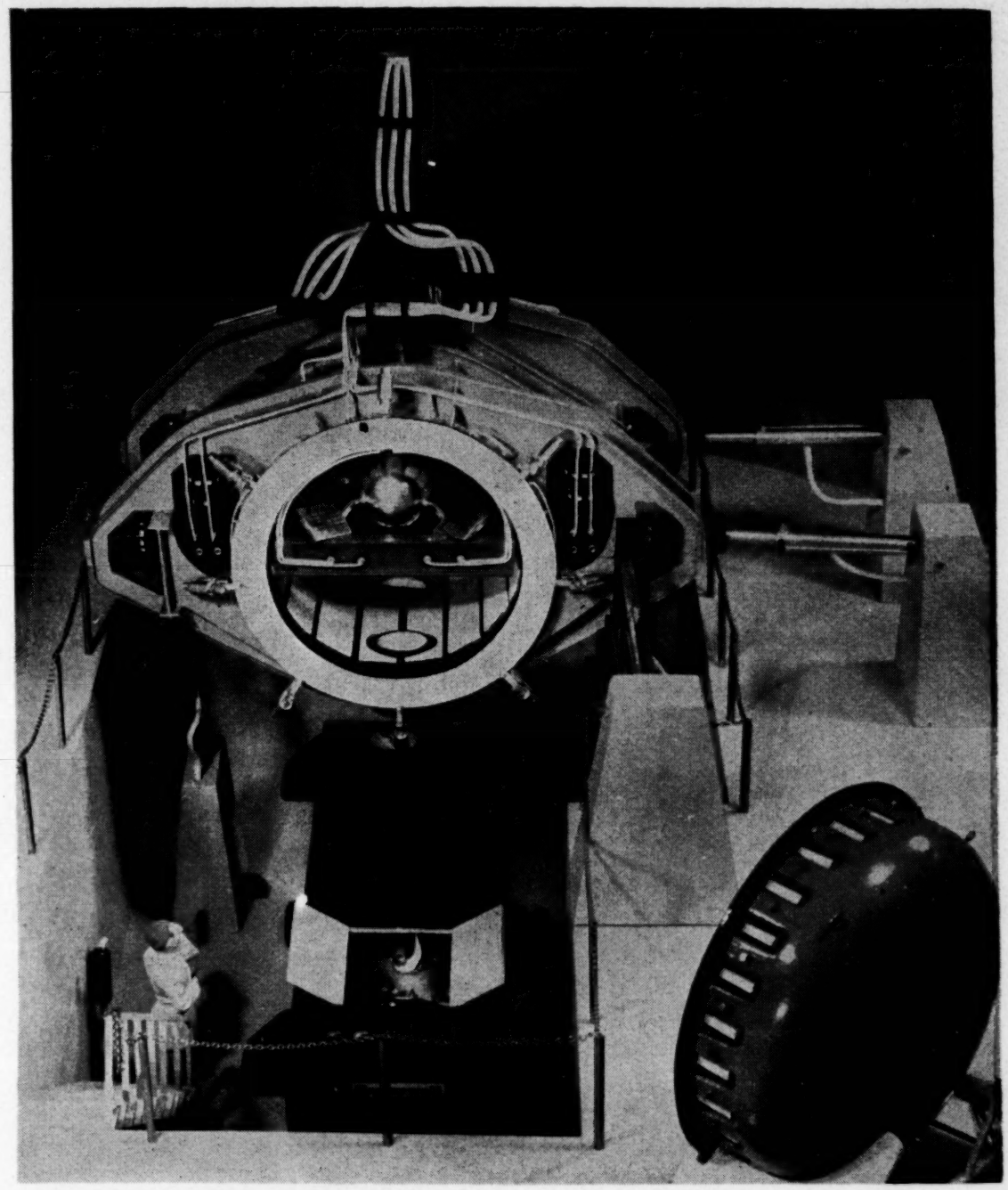
• **Icing Tests.** The KC-135 is a versatile vehicle and can be converted to a variety of jobs. As a flying ice wagon, it carries a supply of water that can be sprayed in controlled amounts and droplet sizes from a shower-head gadget on the refueling boom. This way, flight tests of aircraft anti-icing systems can be made without the necessity of packing up and traveling miles to get natural icing conditions. Furthermore, these tests have controlled icing as a basis, so that the test conditions can be repeated.

Not all of Colligan's outfit flies airplanes, and not all of the tests are flight tests. One of the more unusual jobs done by the D/T&S was a series of spin tests of the B-70, performed with dynamically similar models dropped from the heights of a borrowed Navy blimp hangar at Elizabeth City, Ohio. Photographic instrumentation covered the drops from the 180-ft. height. Major advantage of this type of model spin test, as contrasted to those done in spin tunnels, is that the entry conditions are repeatable, and controllable.

The future promises even a wider range of jobs to tackle in the D/T&S. Colligan expects that some of his officers will be flying airplanes for a long time to come, but that others will be increasingly concerned with non-flight tests. To this end, there are a number of future facilities either under construction, or planned, which will extend the capability of the Deputy even farther into the space environment.

One of these is a sonic test facility now under construction and scheduled to become operational by December, 1962. This building and associated equipment will be able to take large, complete missiles, aircraft, or subsystems into a test chamber 40 x 60 x 70 ft. in dimension, and subject them to a variety of sonic tests, both reverberatory and anechoic. A sound source with a maximum rating of 174 decibels will be used to load the specimens.

Another unique piece of test equipment is the Systems Dynamic Analyzer, an environmental chamber now being built by Minneapolis-Honeywell for installation here and for operations by May next year. The SDA will be able to house complete spacecraft and subject them to the environmental conditions of space plus the external loads of launch or orbital changes.



SYSTEMS DYNAMIC ANALYZER for duplicating effects of space environments on spacecraft is being built by Minneapolis-Honeywell for ASD's Deputy for Test and Support.

Currently these jobs and their supporting activities are handled by three test and two support directorates. Engineering Test Directorate has operational control over ground test facilities, such as the SDA, or the still-unfinished nuclear test facility. Flight Test does what the name says. The Test Data Directorate has the really tough job; design, development and operation of the test instrumentation and data systems, whether optical, electronic or mechanical.

Directorate of Supply and Services worries about anything anybody needs to help him test.

Directorate of Maintenance has the job of repairing and maintaining the aircraft, the test equipment and the facilities that make up the physical assets of the D/T&S. They also handle experimental fabrication for one-of-a-kind parts needed in test work. Colligan has high praise for this unit, which has the difficult task of doing experimental work on a wide variety of airplanes and vehicles of which no two are really alike.

Once the system has passed this phase of its life cycle, it is ready for the operational inventory. There will continue to be tests, or modifications during the service life of the system, and for those reasons the system itself never really leaves ASD, even though it may be nearing obsolescence in the operational inventory.

Equipment Management

About one-third of all the dollars spent buying aeronautical systems goes toward purchasing equipment and services. This represents more than half of the procurement actions of ASD.

This enormous area is managed by a recently established organization, the Deputy for Equipment Management, headed by Col. W. M. Davis. Primarily, this office concerns itself with Government-Furnished Aircraft Equipment (GFAE); to a lesser extent, it may concern itself with Contractor-Furnished Equipment (CFE) or with other equipment or services.

GFAE covers a multitude of items,

PORTABLE NOISE SUPPRESSOR

developed or bought by contract between the government, in the person of the USAF, and a vendor. These items, which include propulsion, bombing and navigational, communications, reconnaissance, flight control and photographic systems, are then acquired by the industrial prime contractor to install or apply to the particular aeronautical system he is developing.

There are related items which also come under the eye of the Deputy for Equipment Management. Product improvement for GFAE items is a very important one. So are the technical orders and handbooks, technical order compliance kits, special tools and ground equipment.

In the list of non-related items, the D/EM has responsibility for buying all photographic equipment for the three services under a single-service procurement assignment. The Deputy also manages the acquisition of equipment and services for the Foreign Technology Division, the AF Technical Application Center and the Intelligence Center. He also manages the purchase of non-standard ground equipment and items developed by the Air Force for other services.

All this involves about 1,000 active GFAE items plus several hundred related items. Earlier this year, the D/EM was managing a total of 3,820 active contracts with about 1,000 contractors for a face value of something over $6 billion.

And, as if sheer numbers and diversity weren't complicated enough, the real problem in some of the systems comes from their lead times, which are often greater than that of the airframe in which they will be installed. Program release, funding and contracts for engines may have to precede those for the airframe by three months; bombing-navigation systems may reach ahead five or six months, and fire-control systems perhaps four months.

To do this welter of things, the D/EM is divided into four Directorates, one each for aeromechanical, avionics, GFAE control, and specialized procurement. There are five project officers, who are the point of contact in D/EM for the various SPOs in the Deputy for Systems Management. There is also an administrative office to handle the day-to-day operations of the Deputy.

Center Support

ASD's GAM-87A Skybolt program is a typical example of the integration of support capabilities within Air Force Systems Command. Skybolt will be tested in component form or as a complete system at every one of the Command's Centers.

In early conceptual and design phases of the Skybolt vehicle, extensive wind tunnel work and background at Arnold Engineering Development Center contributed to the aerodynamic derivation of Skybolt's shape, particularly that of its nose cone.

Background work in electronic countermeasures and other fields of avionics activity, conducted at Electronic Systems Division's Rome Air Development Center, has made major contributions to the effectiveness of the Skybolt.

At the Air Force Missile Development Center, track tests in the Central Inertial Guidance Test Facility have been scheduled to prove out some of the functions of the Nortronics guidance system for Skybolt.

Principal development Center for the program will be Air Force Special Weapons Center, whose special capability lies in matching nuclear warheads to the rest of a weapon system. They will also contribute to studies of increased effectiveness of warheads, effects on targets and assessment of possible damage potential.

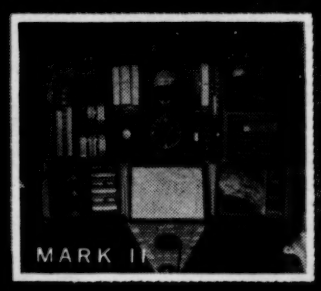
Electromagnetic environmental testing of the Avro Vulcan bomber, Royal Air Force's carrier for the Skybolt, was accomplished at the Air Force Flight Test Center. AFFTC also participated in and supported other portions of the Skybolt program.

Flight test phases of the Skybolt development will be based at Air Proving Ground Center, Eglin AFB. All flight test work with dummy missiles, up through drop tests of Skybolt from its B-52 carrier, will be done over the Gulf ranges of APGC.

Finally, the hot firings will be done on the Atlantic Missile Range with the support of the Air Force Missile Test Center. Planes will be readied and take-offs made from APGC.

BOEING B-52H WITH TWO GAM-77 HOUND DOGS

Pioneers in mission management



supersonic fighters

supersonic bombers

space exploration

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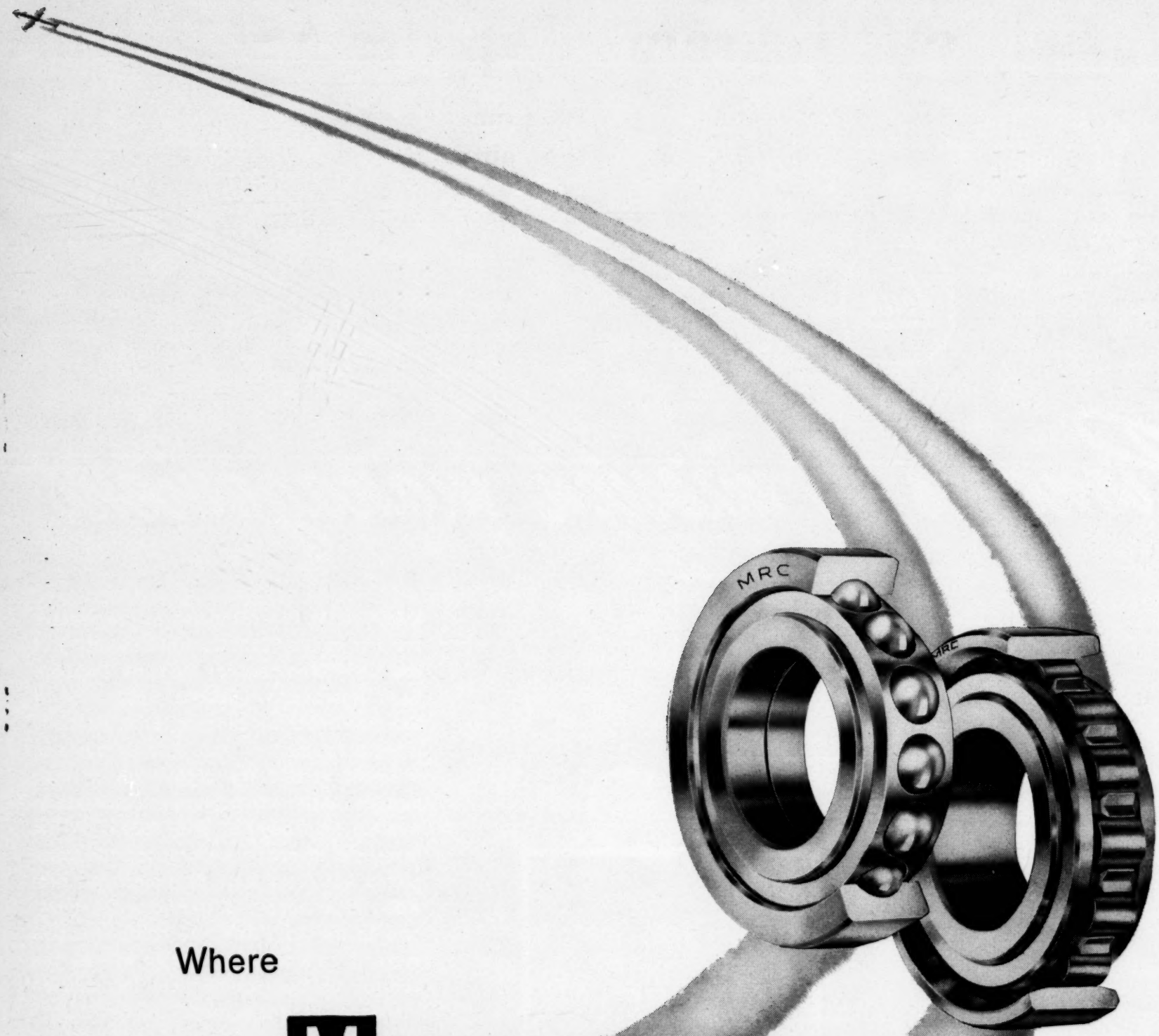

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Variety of Programs Typifies ASD Effort

Systems Program Offices manages Dyna-Soar manned spacecraft, Skybolt, B-70, C-141 cargo aircraft.

Wright-Patterson AFB, Ohio—Four major developmental programs, managed out of Systems Program Offices here, typify the variety and scope of the work of Aeronautical Systems Division of the Air Force Systems Command.

They cover the speed range from zero to 18,000 mph. and reach from sea level to orbital altitudes. They are manned aircraft and unmanned missiles. They carry payloads which can destroy a target or supply a division. They are:

- **Dyna-Soar manned aerospace craft,** a joint Air Force-National Aeronautics and Space Administration research program aimed at exploring manned flight in space environments.
- **Skybolt air-launched ballistic missile,** a joint USAF-Royal Air Force project with a common objective: to increase the striking power of two bombers, the Boeing B-52H and the Avro Vulcan B Mk. 2.
- **B-70 Mach 3 air vehicles,** a highly controversial, emotionally charged program originally planned to produce supersonic bombers, but now aimed at demonstrating design concepts.
- **C-141 cargo aircraft,** combined with Materials Handling Support System 463L to provide a modern cargo carrier by 1965 for military and civil use.

Each of these programs, along with nearly 50 others, comes under the organization of the Deputy for Systems Management, Brig. Gen. A. T. Culbertson. One of them—the B-70—has special status. Head of B-70 project is Brig. Gen. Fred J. Ascani, who also carries the title of Deputy Commander for B-70 in the ASD organization.

Management of these projects involves coordination with other organizations that support ASD, such as the Arnold Engineering Development Center, or the Air Proving Ground Command. It means close working with the industrial contractors who engineer, develop, test and produce the components and subsystems that make up these four projects. It requires liaison with other government agencies, such as the National Aeronautics and Space Administration, Atomic Energy Commission, the Federal Aviation Agency. And finally, it even involves the protocols of relations with a foreign country—the United Kingdom—and British contractors on the Skybolt program.

DYNA-SOAR

Dyna-Soar is a new kind of glider which will be boosted into suborbital or orbital flight, re-enter the atmosphere and fly under pilot control to a conventional landing on a conventional runway.

This simple statement of purpose covers a multitude of technical problems that are being tackled at every level, and some that haven't been thought of yet.

Current Booster

Basically, the Dyna-Soar glider is a delta-winged, snub-nosed aircraft. Current booster is a modified Titan II. A transition section between booster and vehicle houses an escape rocket and some expendable equipment.

Over-all management responsibility lies in ASD in the Dyna-Soar System Program Office, composed of about 200 personnel. Representatives of NASA are included in the SPO.

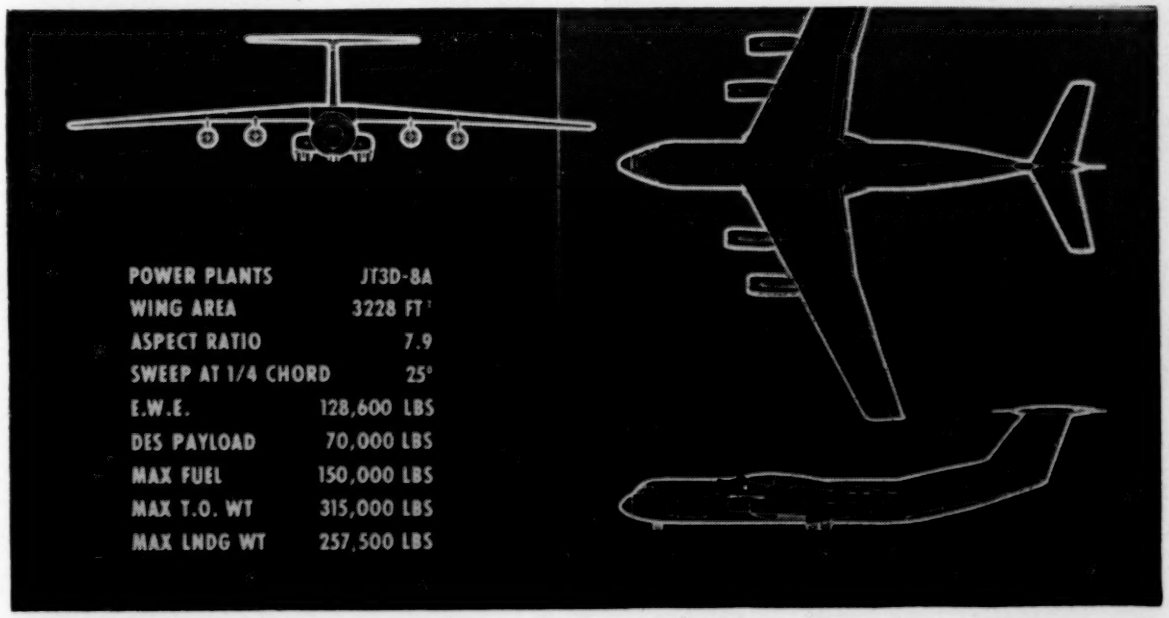
Basic management concept was decided two years ago when Boeing Co. was named as system contractor and the Martin Co. was chosen as associate contractor for the booster.

Space Systems Division of AFSC is responsible for management of the booster modification and development of the ground support equipment. Industrial teams working on contract to SSD are Martin and Aerojet-General.

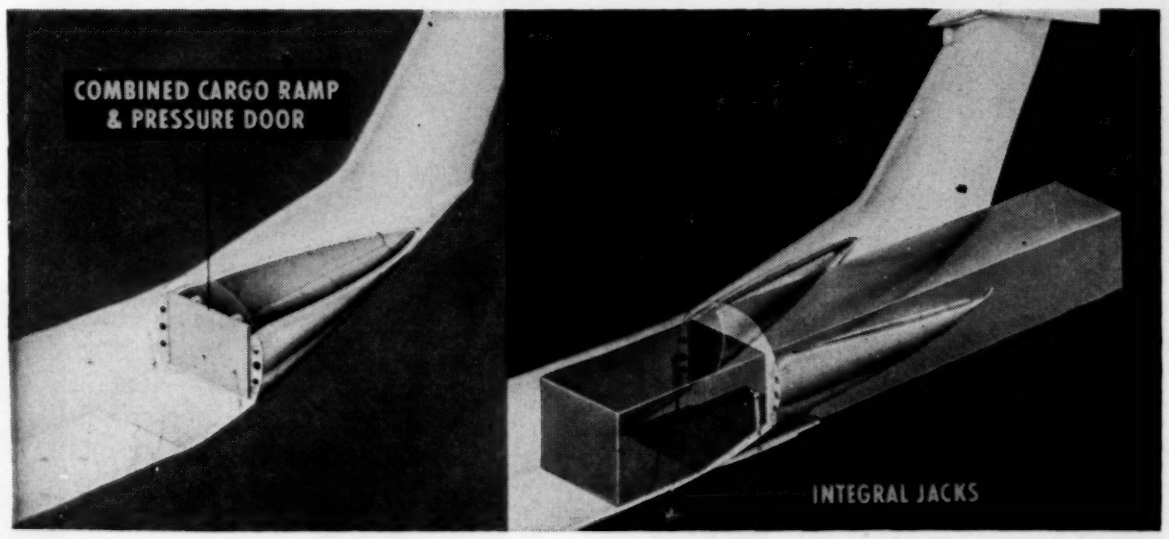
Boeing's task is to supply the glider and its ground support equipment, as well as to integrate and test the whole Dyna-Soar system. Minneapolis-Honeywell will deliver the guidance subsystem, and Radio Corp. of America will be responsible for the communications package. There will also be associated equipment furnished by USAF to the contractors as Government Furnished Aircraft Equipment (GFAE).

Subcontractors have been selected; an architectural engineering firm has started planning the launching facility.

Air Force Flight Test Center at Ed-



LOCKHEED C-141 CARGO TRANSPORT



C-141 AFTERBODY AND DOORS

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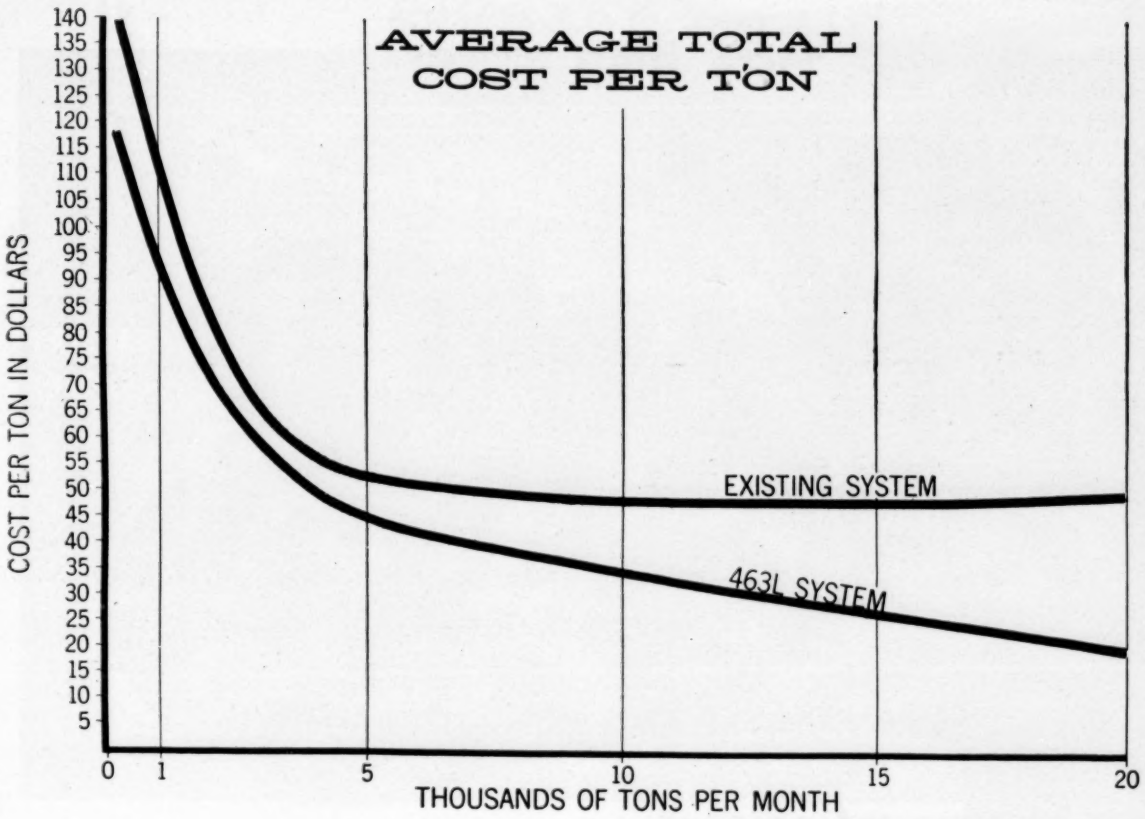

COST EFFECTIVENESS FOR C-141/463L

wards, where pilots will be selected and trained, has been brought into the program. So have the Air Force Missile Test Center, the Oklahoma City Air Materiel Area, NASA's Flight Research Center and Langley Research Center. Air Proving Ground Center will start test work on the guidance system components next year.

Dyna-Soar Requirements

Obviously the Dyna-Soar vehicle bridges a gap between the conventional air-breathing craft of today and the deep-space craft of the future. It can serve as a laboratory to advance technology, to prove concepts, to test specific systems.

Basically, the Air Force wants the Dyna-Soar to be a hypersonic test vehicle to explore the flight regime over a wide range of lift coefficients. In doing this, the program will make basic contributions to the fields of aerodynamics, structures, and materials.

Such a vehicle must be maneuverable, the Air Force says, because it will help determine the feasibility of using maneuvering capabilities in future systems. It also means the Dyna-Soar will be able to use ranges and landing fields that now exist.

The value of a piloted vehicle is to learn more about the man-machine relationship in a space environment. The combination of a piloted, maneuverable craft means that Dyna-Soar will be both recoverable and reusable.

Finally, the orbiting capability of Dyna-Soar means that Air Force will have a space laboratory, a flying test stand in which to prove systems and components that have never before been subjected to the torments of space.

Current plans for the program divide it into three steps, of which only the first has been approved:

- **Step I:** Suborbital research program in hypersonics, up to velocities of 22,000 fps., proving the basic capability of a glide vehicle during re-entry and landing.
- **Step II:** Research and development flight tests of a glider in orbit, plus definition of man-machine relationship under orbital conditions and determination of the military potential of the system.
- **Step III:** Weapon system based on findings of Steps I and II.

Glide Tests

Step I will begin, as did the programs of so many earlier research aircraft, with glide tests made by dropping the Dyna-Soar glider from a carrier aircraft, in this case a Boeing B-52. These flights will include powered runs using the acceleration (escape) rocket; Dyna-Soar performance envelope under these conditions will still allow it to operate within the limits of the range at the Air Force Flight Test Center, Edwards AFB.

From Edwards, the Dyna-Soar vehicle will be taken to the Atlantic Missile Range for boosted launches into the hypersonic regime. In this series of tests, downrange landing fields will have to be prepared. Such a field is being planned for construction on the northern coast of Brazil.

Range instrumentation will have to be expanded to cover adequately this portion of the program flight-testing.

At this point, the current Dyna-Soar configuration becomes outmoded. The modified Titan II will not be able to boost the vehicle into orbit. Several other booster layouts are now being studied to do the orbital job. Among

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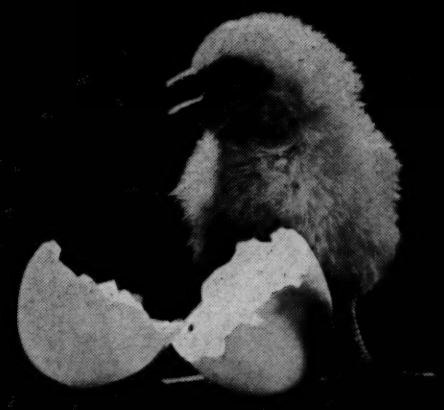

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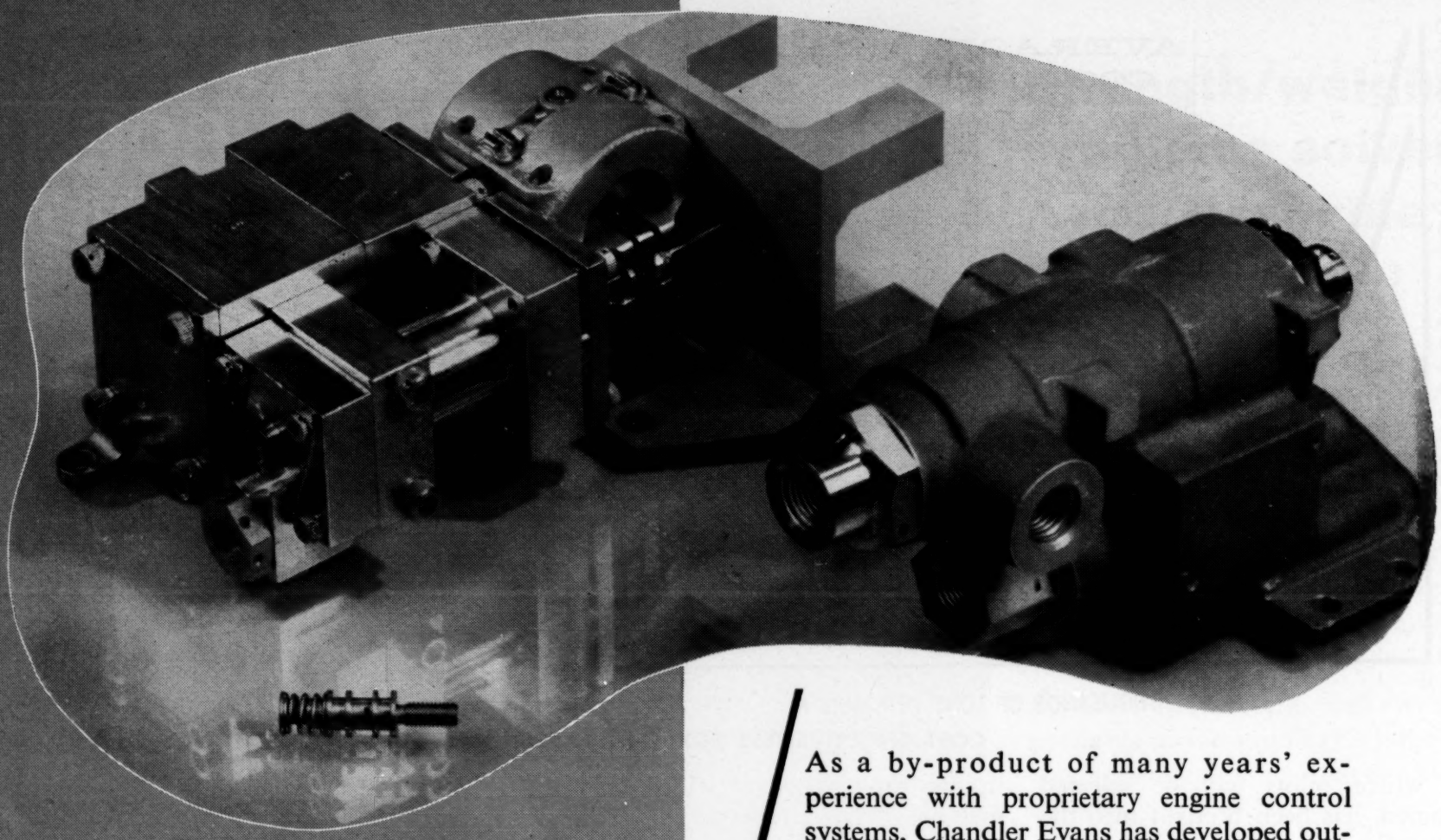

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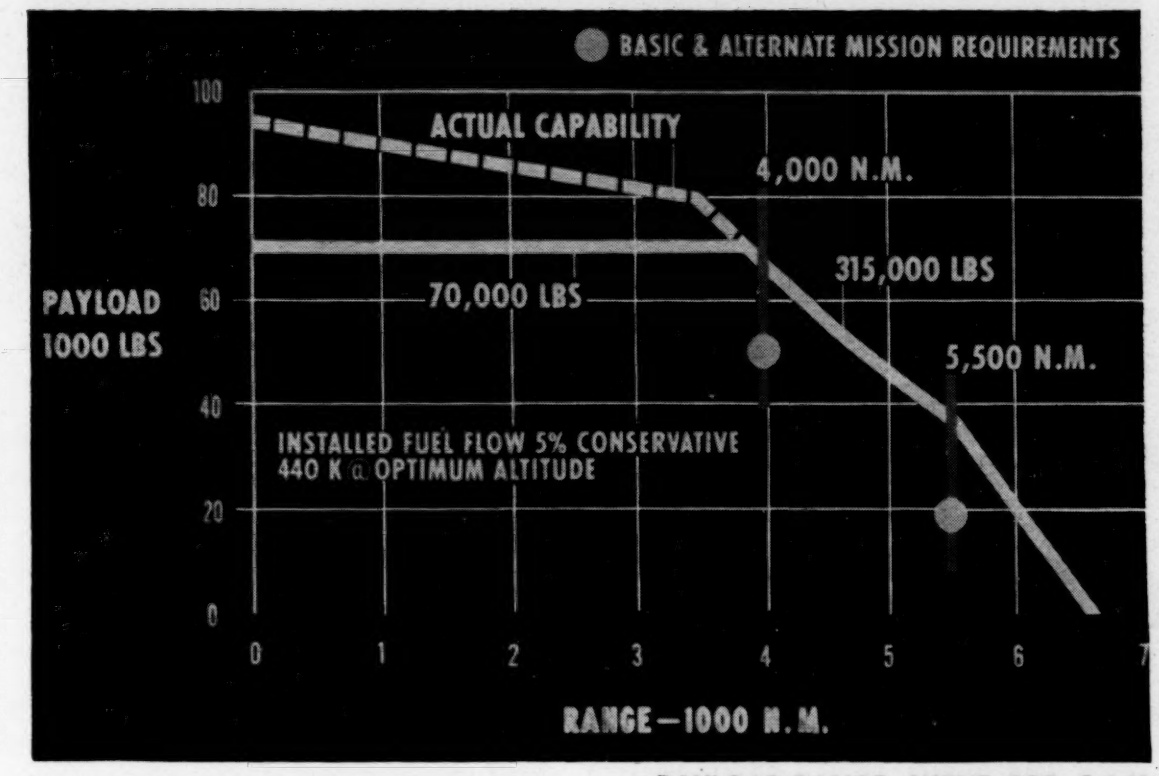


PAYLOAD-RANGE CURVE FOR C-141

them are these three designs:

- **Three Titan II boosters,** clustered around the Dyna-Soar vehicle and its escape-acceleration rocket system.
- **Two finned,** 100-in. diameter segmented solid rockets, one on each side of a Phoenix upper stage and the Dyna-Soar vehicle.
- **Two 100-in. segmented** solids added to the conventional Titan II finned booster and Dyna-Soar combination.

Whichever configuration becomes the final choice, the ultimate flight program will be the same as now planned. The Dyna-Soar will be boosted into a "once-around" earth orbit and land at Edwards AFB.

The present Dyna-Soar layout shows the glider with its rocket acceleration system perched atop the modified Titan II booster. Basic configuration of the glider is a low-winged, tail-less delta of very low aspect ratio, with vertical tail surfaces mounted at the spanwise tips of the wings. Cross-section of fuselage is rectangular with rounded top.

This geometry has evolved from a series of design studies made at Boeing, and by the Air Force and other industrial teams during the intense design competition. The layout has been subjected to more than 15,000 hr. of wind tunnel testing, and there is more to come. The system is expected to be run in every major U. S. facility. In July, the tenth-scale model of the Dyna-Soar plus Titan II was being tested at AEDC in a series of runs with full burning of the miniature Titan booster engines.

This amount of wind tunnel time, is more than went into developmental tunnel work on Boeing's B-47, B-52 and KC-135 combined. It is already three times the amount of wind-tunnel testing done for the North American X-15 research aircraft.

Over-all length of the Dyna-Soar glider is 35 ft. 4 in.; over-all length of glider plus booster is 129 ft. 8.4 in.

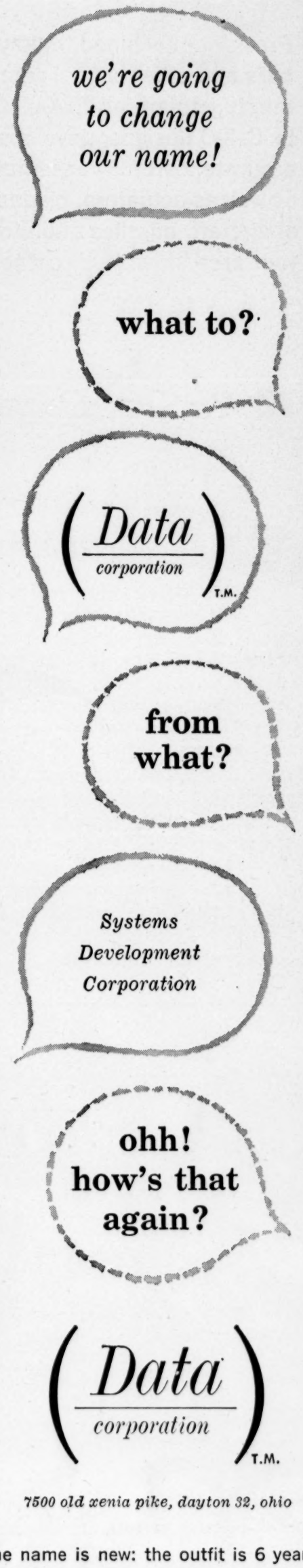
Biggest obvious difference between a standard Titan II and the modified unit planned for the Dyna-Soar is the addition of fins to increase the static aerodynamic stability in pitch and yaw, and thus reduce the amount of control power required by the booster-glider combination during the boost phase.

The basic Titan II features a constant-diameter fuselage from booster skirt to warhead transition piece. This layout, which provides much more fuel space in the second stage than the Titan I configuration, was kept for the Dyna-Soar booster. Fins were added, with areas determined by the requirements for stability and control. Thus the pitch fins are larger than those for yaw stability.

Engines in the Titan II were slightly up-rated for the job. First stage Aerojet-General twin engines will develop 215,000 lb. sea-level static thrust each for a total of 430,000 lb. Second-stage Aerojet-General engine will be rated at 100,000 lb. static thrust.

There is a basic difference in loads applied to the Titan airframe when it is used as a Dyna-Soar booster, compared with its use as an ICBM. Structural modifications had to be made in the tank dome and barrel, and in the interstage skirt. These increased the safety factor of Titan II to about 1.4; that is, the modified missile should be able to take about 40% overstressing without breaking up. The Titan II missile cannot do this, nor was it intended to in its ICBM role.

A malfunction detection system, similar to that installed in the Convair Atlas boosters for the Project Mercury orbital shots, was added to the Titan II. This system will monitor several



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key parameters constantly during the boost phase of flight, and initiate escape action in the event of trouble at any time.

This combination of the modified Titan II and the Dyna-Soar is expected to be capable of suborbital flights up to velocities of about 22,000 fps.

Critical Phases

Recovery and landing after recovery are probably the most critical phases of the flight profile. Ten thousand pounds of steel and exotic materials, bearing a live cargo, must be eased down through the upper reaches of the atmosphere. Even this thin air causes enough skin friction at the high speeds of re-entry to raise the leading edges of wing, fuselage and tail to red or yellow heat.

The air gets hotter, and where it becomes dense enough, a strong shock-wave pattern develops. The air around the Dyna-Soar becomes ionized and interferes with normal communication operations.

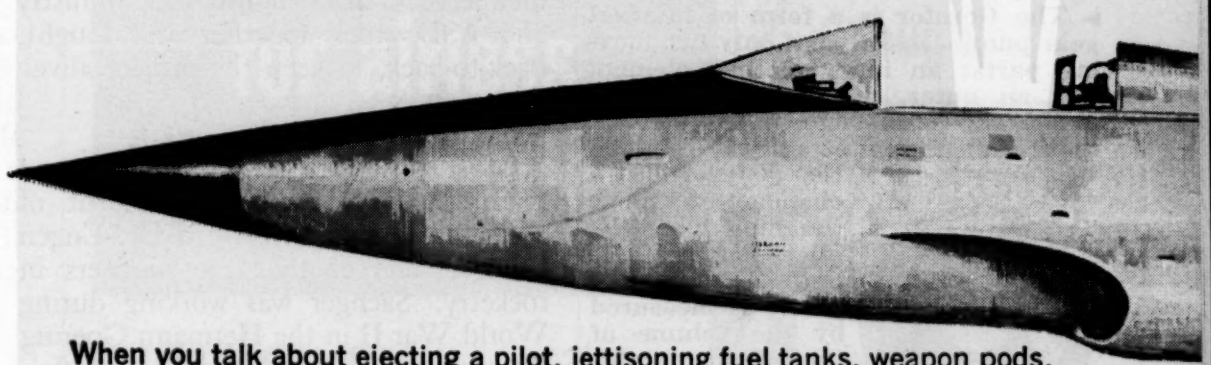
Even though the craft is maneuverable, it is not infinitely so, nor can it be landed just anywhere. It will use skids, not wheels. The pilot faces a problem of energy management so that he can get to his planned destination and not overshoot or undershoot. One analogy used by an ASD engineer is this: You are given an automobile with a full tank of gas feeding an engine which only has one throttle position: wide open. You have to drive the car to a specified destination and arrive with a dry tank. You may use only the brakes during your trip; if you use them too much, you run out of gas and fail to arrive. He might have added that if you make a mistake in planning this trip, and arrive with gas left over, or run out along the way, the chances are good that you will be killed. This is roughly the task that faces the Dyna-Soar pilot.

Management of this project is exciting enough now for those in the Aeronautical Systems Division Dyna-Soar SPO. But ASD has made many other contributions to the Dyna-Soar program, dating back through the years.

Programs Pushed

The ASD Materials Laboratory, which first became interested in the high-temperature materials problem in the early days of the turbojet engine, has spearheaded many basic programs for newer and better materials to withstand the fantastic heating rates of re-entry. ASD's structural test facility will have tested the glider structure, whole and in pieces, before flight. The Aerospace Medical Laboratory, which is organizationally assigned to ASD although reporting as a part of a special group in the Command, set the pace for de-

how to drop a pilot straight up...



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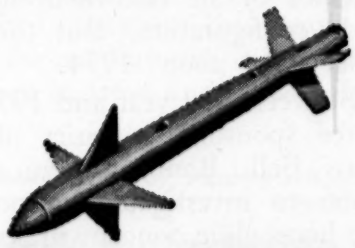

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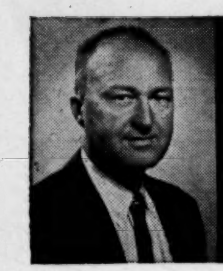

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► **The Gerotor is a form of internal gear pump consisting of only two moving parts: an inner toothed element and an outer, meshing toothed element. The inner element has one less tooth than the outer and the "missing tooth" provides a chamber to move the fluid from the inlet port to the outlet. Pump capacity is measured by the volume of the "missing tooth" multiplied by the number of driver teeth and RPM.**

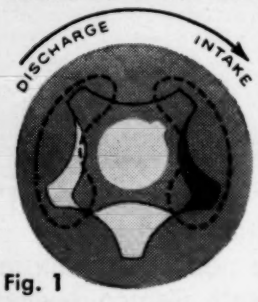
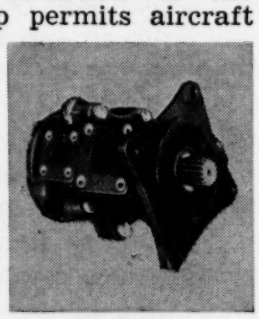
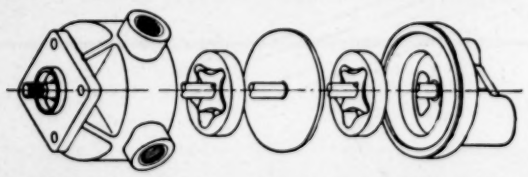


Fig. 1

► The unique construction of the Gerotor type pump permits aircraft systems designers to combine *several pumping functions* in a single pump housing mounted on a single pad and driven by a single shaft. Diversified systems such as lubrication, scavenging, low pressure hydraulic servo systems and motors up to pressures of about 1000 psi may be centralized in this manner.



Multiple function pump.



► **The Gerotor pump is a positive displacement type, delivering a predetermined amount of fluid in direct proportion to speed. It is a form of internal gear pump—simple and compact in basic design, (has only two moving parts). It is lightweight, valveless, provides exceptional performance at high altitudes and has low wear over a long service life. In addition, it is balanced and extremely quiet in operation.**

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velopment of the flying suit that will keep the pilot alive and comfortable. Communication through the ion sheath, calling for super high frequencies, will be possible because of pioneering work growing out of the long-standing advanced airborne electronics program here. The pilot's adaptive control system originated in conceptual form in ASD's Flight Control Laboratory.

During the years that preceded the start of tangible progress on Dyna-Soar, many industrial teams made major contributions to the entire program. And during the funding and program schedule changes that have hampered Dyna-Soar progress, industry and ASD stuck together and fought, back-to-back, to keep the project alive.

Project History

Most observers of the progress of manned flight credit the concept of the boost-glide trajectory to Dr. Eugen Saenger, one of the true pioneers in rocketry. Saenger was working during World War II in the Hermann Goering Research Institute, the Luftwaffe's equivalent of ASD, when he thought of the idea. In its final form it appeared as a monumental report presenting the now famous "antipodal bomber," a 110-ton aircraft capable of a once-around-earth orbit.

It was too far ahead of the contemporary technology to be bought, and about the only use ever made of the data was that some of it was picked up by the rocket development group at Peenemuende. It was later used as the basis for one of Peenemuende's Archiv 66 reports outlining a way to hit New York with a two-stage A9/A10 rocket vehicle. The only difficulty there was that the Peenemuende group used some data that Saenger had extrapolated badly and which finally gave highly optimistic ranges for the A9/A10.

Copies of the Saenger report reached the U. S. and also the Soviet Union. In this country, little was done about it; it made interesting reading if you were fluent in German, and the pictures were intriguing. There was a brief flurry of interest in 1947, when a study was made by General Electric's Project Hermes of an ICBM using a boost-glide configuration. But then all was quiet until about 1954.

Between that year and 1957, the Air Force sponsored a series of studies—Brass Bell, Bomi, System 118P and Robo—to investigate the potential of the boost-glide concept in some depth. Toward the end of that period, the National Advisory Committee for Aeronautics (now NASA) conducted its own study in Project Hywards and concluded, as had the Air Force, that the time to develop hardware had arrived.

Those conclusions came out of the results of the studies, which made two major points: First, the boost-glide concept could yield very attractive military systems; second, the technological problems could be defined then in enough detail to chart a rough development course.

NACA and Air Force, fully aware of each other's studies and aims, decided to collaborate in the development of a system that would meet both sets of objectives. The Air Force wanted to be able to investigate the military uses of hypersonic and orbital flight; the NACA wanted to study hypersonic flight and re-entry conditions.

Boeing and Martin were invited to make preliminary design studies in 1958, and these designs were later evaluated by handpicked teams from Wright Field aided by representatives from NACA, Strategic Air Command, Air Materiel Command and Air Force Ballistic Missiles Division.

Boeing was chosen as systems contractor in November, 1959, and Martin was picked as associate contractor for the booster.

At this point came the first snag; Department of Defense would not give its approval for the program to proceed. Before they would, they indicated they wanted a study of the entire field of re-entry and boosters to determine if the proposed approach were the optimum.

Phase Alpha

Phase Alpha, the name given to this study, began the following month, led by the joint effort of industry and ASD. Boeing organized a group with specialized capability in the field of re-entry; Air Force also fielded a strong team. With more than 150 personnel from Wright Field alone, the "Dyna-Soar Ad Hoc Group" started to look at the program from its foundations all over again. They looked at 11 re-entry vehicle configurations, including a pair which had been conceived at ASD.

In April, 1960, the Ad Hoc group concluded Phase Alpha, verifying the original approach in every aspect, and bringing out even more clearly the kinds of problems needing immediate solutions.

That month DOD gave the go-ahead signal to Dyna-Soar.

SKYBOLT

Skybolt (GAM-87A) is a ballistic missile designed to be carried aloft under the wings of strategic bombers and launched before the bomber comes within effective interception range of enemy aircraft or missiles.

As a joint USAF-RAF program, Skybolt is being developed toward a com-

mon objective of both services: development of a stand-off weapon that will increase both the striking power and the useful life of the subsonic Boeing B-52H and the RAF Avro Vulcan B Mk. 2 bombers.

Over-all management of the program is the responsibility of the Skybolt System Program Office in ASD. Seven Air Materiel Areas support the program, with the Oklahoma City AMA responsible for supplying the B-52s needed. Although ASD and the Air Force Special Weapons Center are the principal members of USAF's development group, all the Systems Command Centers will be used to some degree. For example, all missile test flights, with the exception of "hot" firings, will be performed at Air Proving Ground Center, Elgin AFB. The "hot" firings will be done on the Atlantic Missile Range after takeoff from Eglin.

Training in Skybolt will be the job of Air Training Center at Lowry AFB, under over-all direction of Air Training Command headquarters.

Industrial Effort

Douglas Aircraft Co. is weapons system manager on the industrial side, with three principal subcontractors: Aerojet-General for the solid-propellant propulsion system; General Electric for the re-entry vehicle; and Nortronics for the guidance system. Bendix, developing a standardized ground-support unit, and A. V. Roe, developers of the Vulcan bomber, are associate contractors to Douglas on the program.

The most unusual aspect of the contract between USAF and Douglas is that it defines no hardware. Instead, it says what the operational and technical requirements must be for the system, and gives the Douglas company the necessary resources to demonstrate to USAF that they have met the objectives of the contract.

Further, much of the actual demonstration of the fulfillment of objectives will be done by Air Force personnel operating the Skybolt system. Although the contractor will begin the flight test program, it will shift to the purview of Aeronautical Systems Division as soon as feasible. The whole purpose is to get the weapon into the operational inventory as fast as possible, and to get feedback from the using Commands —SAC and the RAF—into the development of the system at the earliest possible stage.

Management techniques are being applied to the Skybolt program, ramrodding it at every stage of the development. PERT—Program Evaluation and Reporting Technique—approach is being used to chart the step-by-step development of subsystems and major components and to predict scheduling

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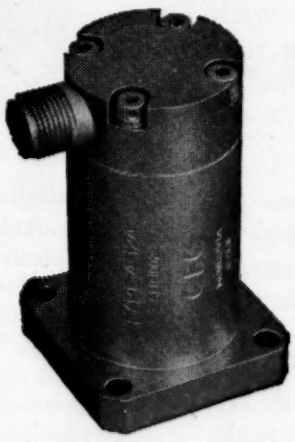

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trouble far enough ahead to do something about it.

ASD says that the program is on schedule, and is meeting both its technical and managerial objectives. There are those who would quarrel with that statement.

The division also lists some milestones:

- **Basic missile system** configuration is complete.
- **Configuration of the operational** reentry vehicle, now a hemisphere-cone shape, has been established. Choice had to wait for the final payload selection.
- **Flight-weight motor test program** has been completed successfully.
- **Dummy missiles** have been delivered to Boeing, flown through the B-52 Aerodynamic Flight Compatibility Test Program, and dropped on the Eglin range to check separation characteristics. Similar missiles were sent to Britain for flight tests with the Vulcan aircraft, now under way.
- **Skybolt Joint Test Force** has been established at Eglin, with necessary facilities coming into being on schedule.
- **Electromagnetic environmental** testing has been completed at Edwards Air Force Base on an Avro Vulcan.
- **Effective management relationships** have been established across the Atlantic, and two major Anglo-American Skybolt Planning Conferences have been held.

Captive flight test phase of the Skybolt is scheduled for the near future, and this will in turn be followed by programed rounds and then fully guided flight test missiles.

Skybolt has a checkered history that starts back with two ill-fated Air Force projects: WS-110A, the so-called "chemical" bomber, and WS-125A, the nuclear-powered bomber. Both General Operational Requirements for the bombers, dated Mar. 22, 1955, included an advanced air-to-surface missile.

About a year later, ARDC System Requirement 112, dated Mar. 14, 1956, authorized investigation of an air-to-surface missile that could be used by both bombers.

Five studies followed, all under the designation of WS-130A. First of these was by Bell Aircraft Corp., qualified because of its earlier Rascal and Shrike air-to-surface missile work. Lockheed and Convair, working on the WS-125A contract proposals, also investigated the WS-130A design. So did North American and Boeing, which were working on the WS-110A design. The five different approaches were completed by November, 1956, but none of them met the requirements, and so the level of work was reduced for about a year to cover review and up-dating.

System Requirement 168, an unfunded study effort done by industry, kicked off the work on WS-130A again in October, 1957. Purpose of the exercise this time was to determine what general requirements could be met by an air-to-surface missile in the time period around 1963. This time 14 contractors answered the call and worked on proposals.

They reached the same conclusions: Air-to-surface missiles were feasible and adaptable to either known or proposed strategic bombers.

Next move was from Headquarters USAF, which asked for feasibility study on air-launched ballistic missiles used against surface targets. The hunt was on again. Three contractors—Martin, Convair and McDonnell—got one phase each of a demonstration program.

Martin's job was to demonstrate the feasibility of launch from a subsonic vehicle; Convair drew the supersonic launcher assignment. McDonnell demonstrated performance and flight characteristics of a hypersonic, body-lift type of missile. These three efforts presumably met the requirements of the Headquarters, USAF request of January, 1958.

SOR 177

One year later, out came Specific Operational Requirement 177 for the development of a rocket-powered strategic air-to-surface missile system, accompanied by invitations to bid sent to 24 prospective contractors. Proposals were received from 15 bidders. In May the Air Force announced that Douglas had been selected.

Subcontractors had been chosen by October, 1959, just in time to run up against a Department of Defense directive for an Air Force re-evaluation of both concept and development plan for the Skybolt. Industry and the USAF roared through this one by January, 1960, presented the re-evaluation to DOD and received official blessing in February, 1960.

Rough Road

The road continued to be rough: in December last year, Headquarters, USAF requested a re-evaluation of the whole program. There was some frantic footwork, and some intensive paperwork. USAF was convinced again, and the program was reconfirmed in March of this year.

So far, Skybolt has been through five sets of requirements, three demonstration programs, two re-evaluations and at least 37 separate and distinct sets of proposals, including more than one from the same contractor at different times in the hectic life cycle of this missile. In Britain, like the Thor before it, Skybolt was subjected to inquiry by Britain-first politicians, was

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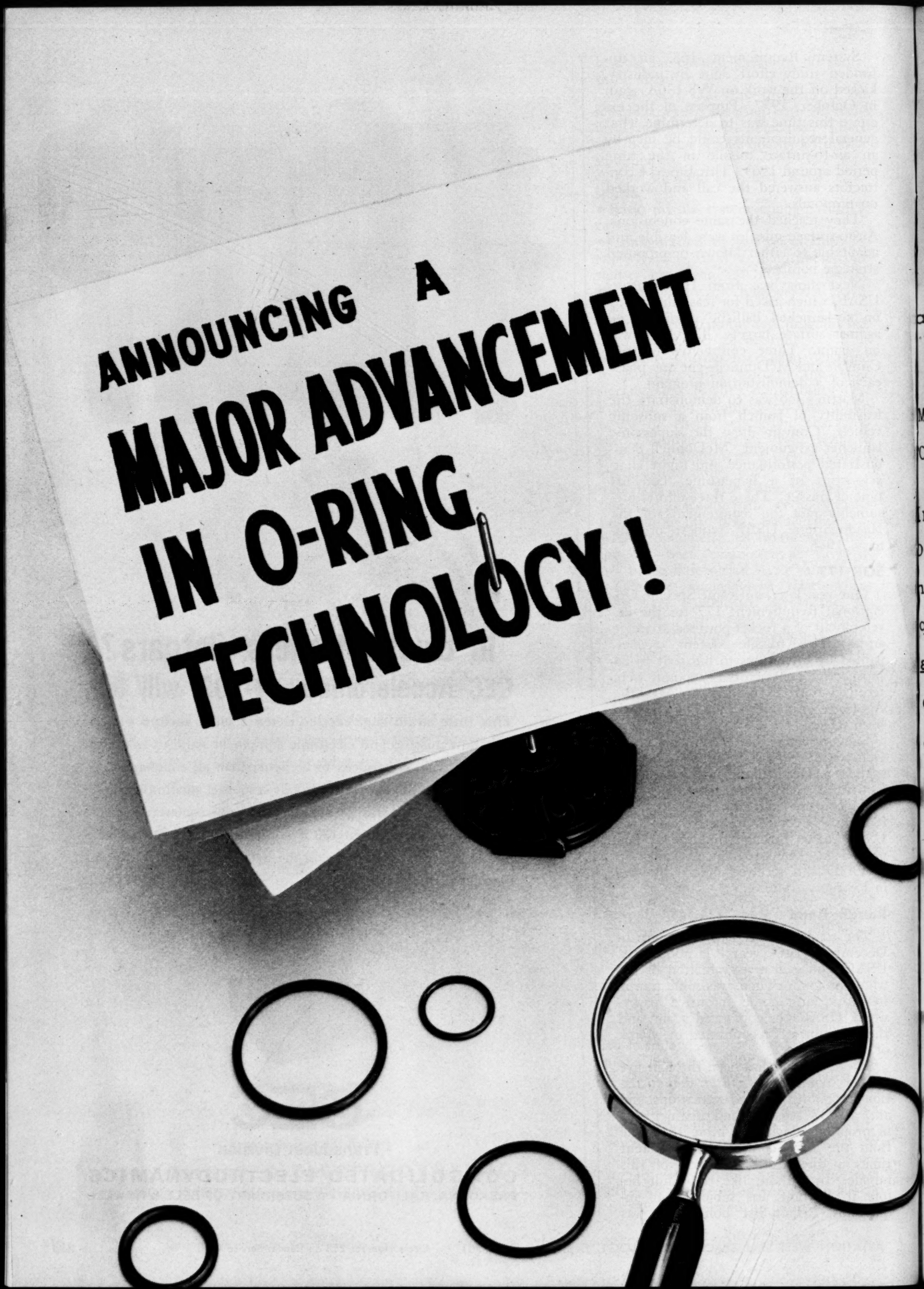
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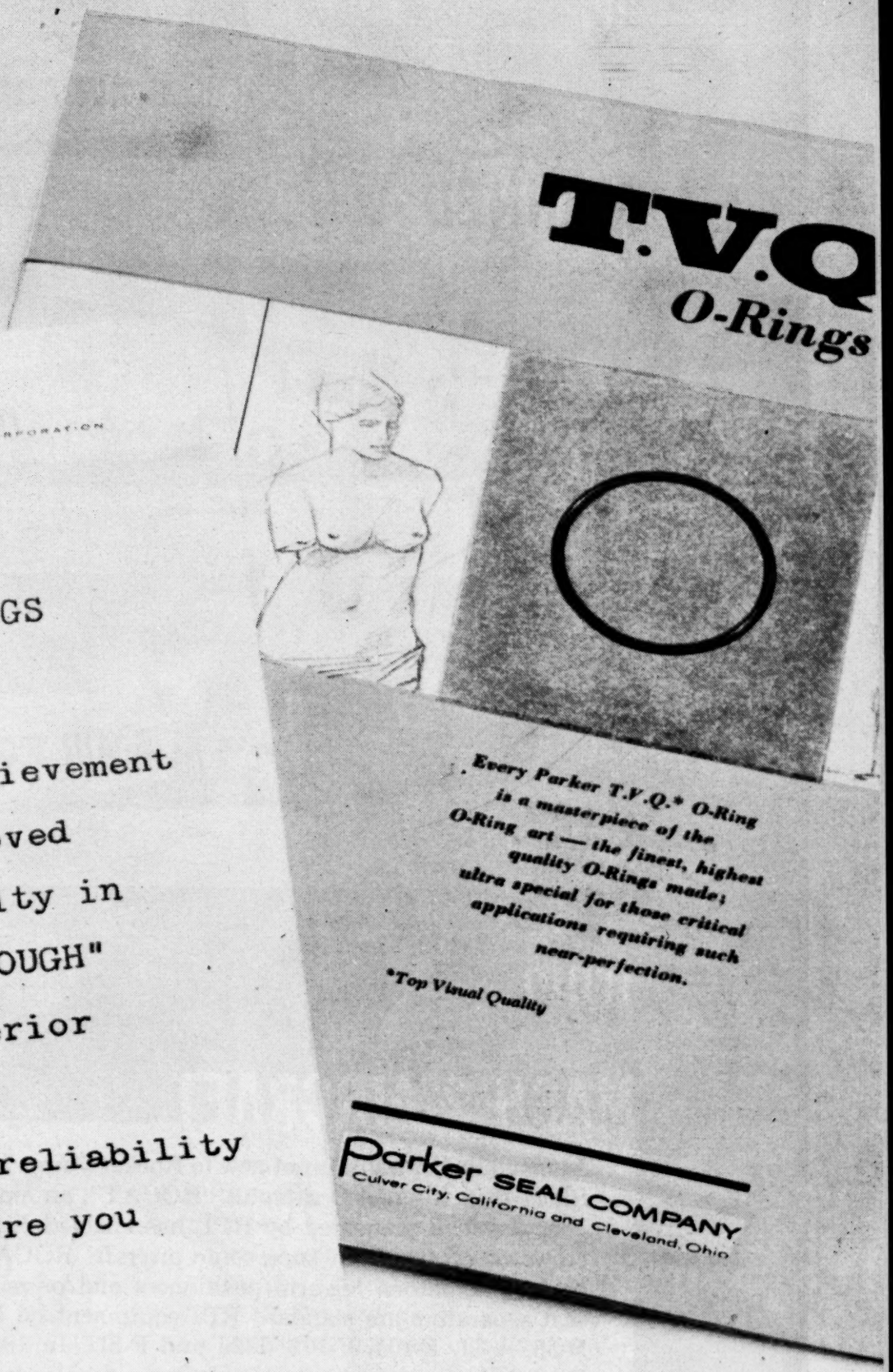

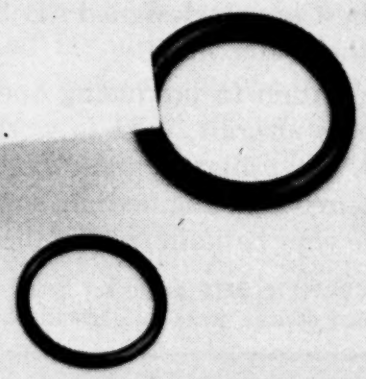

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made the subject of discussion in both Houses of Parliament, and was a target for the British press.

There are few who would contest the concept of the Skybolt, but there are many who would be willing to contest the way the Skybolt program has progressed.

The final proof is still in the future. Skybolt is scheduled to become operational in about another 18-24 months.

B-70

The B-70 program continues on a day-to-day basis at a reduced level of work and expenditures, aimed at producing three non-operational test vehicles at the end of the life cycle.

This redirected program is working within rigid frameworks of time, cost and management control to produce the prototypes and complete their test programs by the end of Fiscal Year 1965.

Managerially, the B-70 is set apart from every other program in the Air Force except the Minuteman missile system. It operates under the conventional ASD System Program Office, but that office is headed by an ASD Deputy Commander, Brig. Gen. Fred J. Ascani. One indication of its high national priority is that Secretary of Defense Robert S. McNamara gets a 30-min. briefing once every two weeks on the B-70.

Ascani's organization is simple and direct. He has two support organizations, one for program control and integration, and the other for administration. There are three Directorates in the SPO: Engineering, Test and Production and Logistics.

In the B-70 re-directed program charter, established May 3 by Gen. Thomas D. White, then USAF Chief of Staff, the project was designated as a system program, with autonomy to stand alone and apart as a high-priority item, and the authority to make that priority meaningful. Through Ascani, the program has access to supporting agencies, and control of its own financial resources. Manpower can be drawn from any location as required.

Executive Council

In addition to this direct system of management, there is an executive council that works on the B-70 project, including the general of the responsible division (in this case, Gen. W. A. Davis, or Ascani acting for him), other general officers and members of industry.

As in other high-priority projects, special attention is given to management aids, such as PERT.

The re-directed program has some new objectives in addition to the old ones specified as part of the original bomber program. Totaling seven, these

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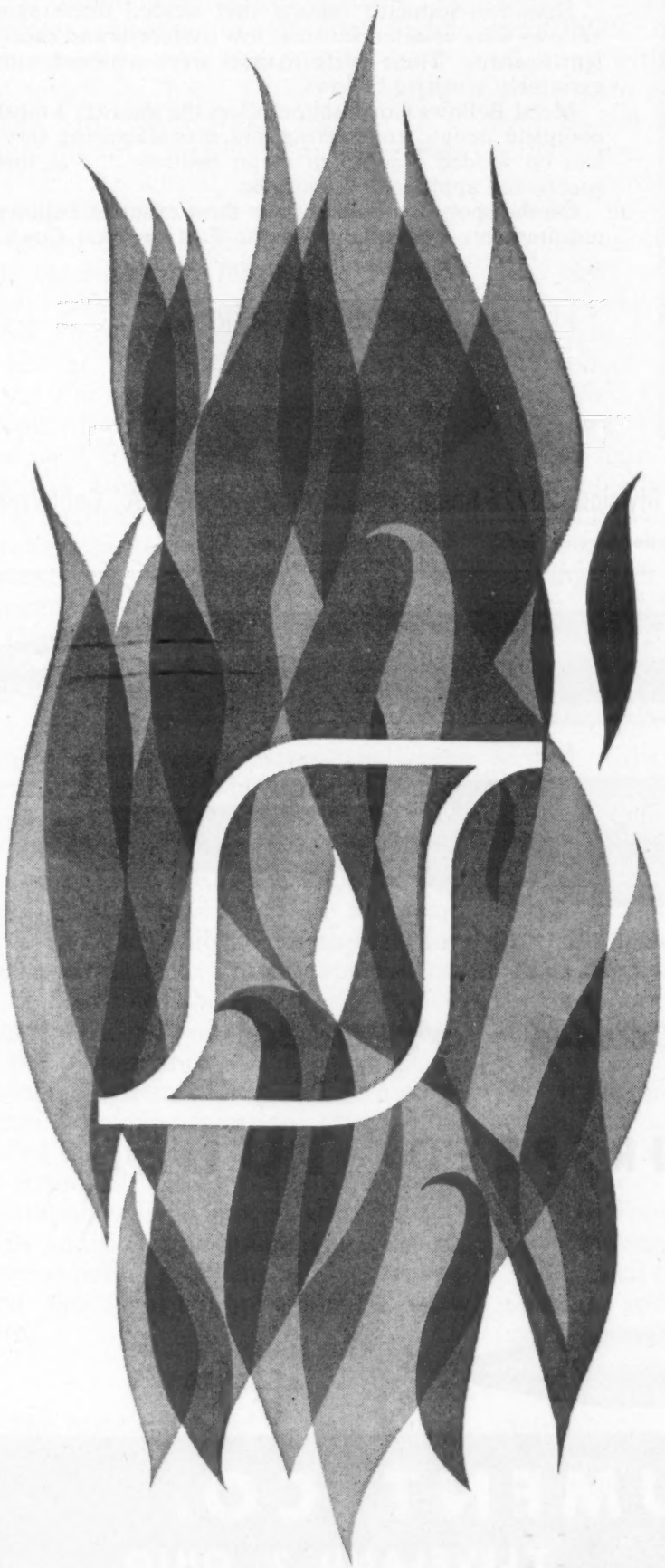

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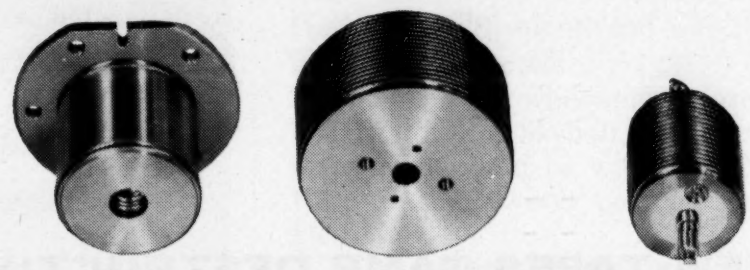

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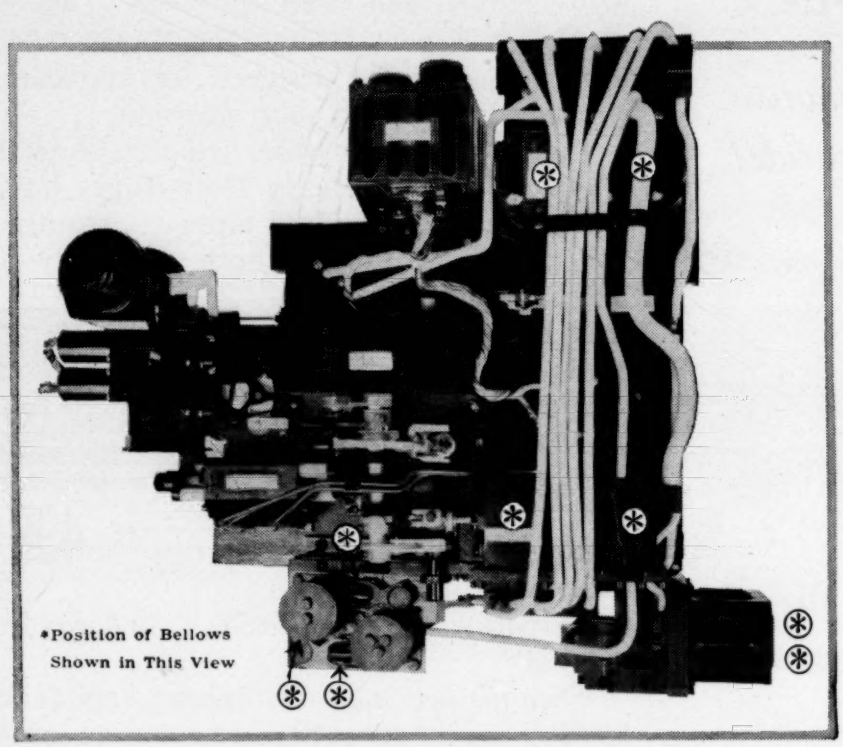

As Seen In a B-70 air inlet control by Hamilton Standard

There are twenty three welded diaphragm bellows in the air inlet control shown here. The assembly includes eight different bellows engineered expressly for the installation.

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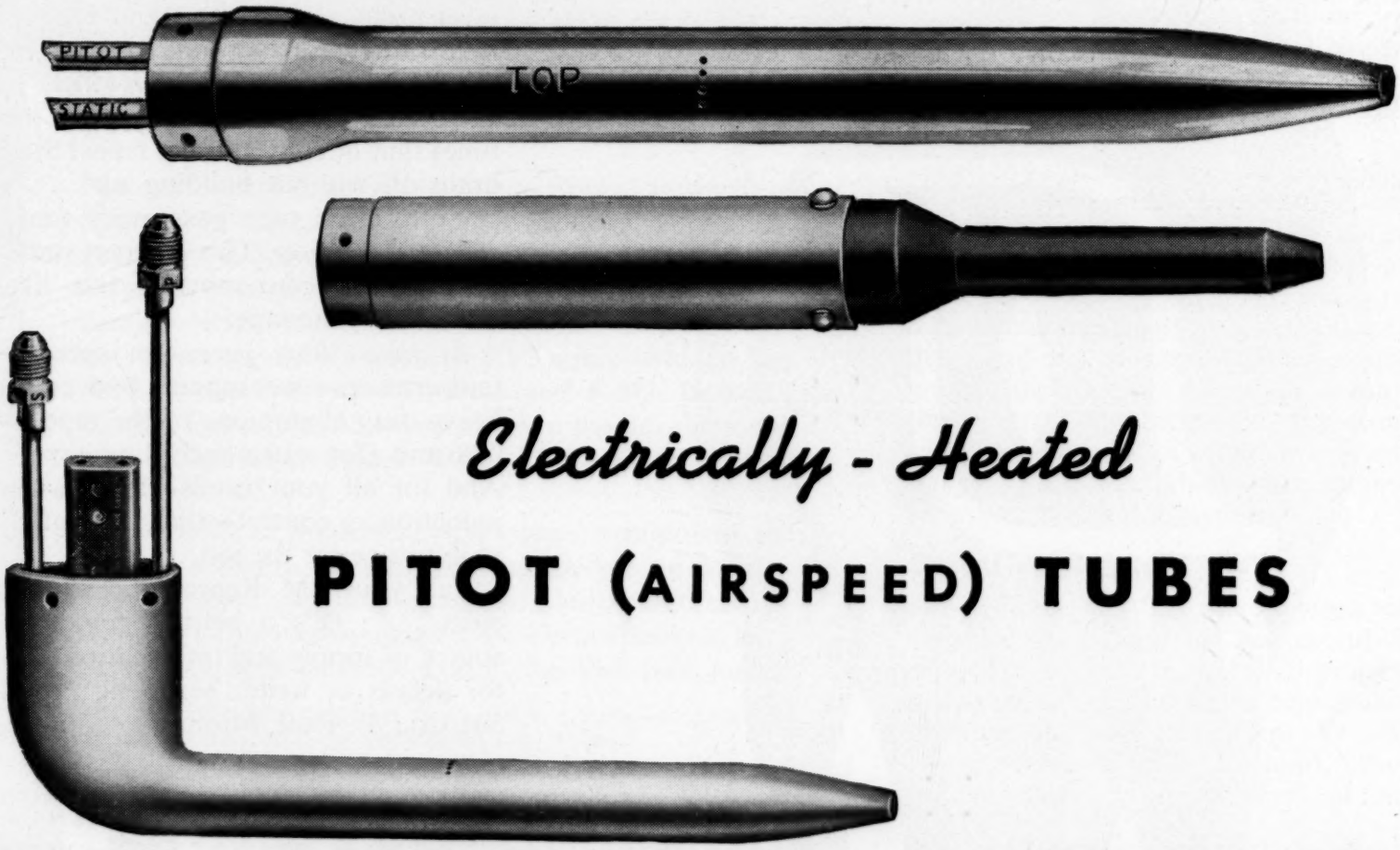

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objectives now are the following:

- **Production of three** prototype air vehicles.
- **Meeting schedules,** particularly first flight data.
- **Limiting cost** to a total of $1.3 billion; a total of $800 million has been committed or spent on the program through FY 1961, with $500 million more to go before June 30, 1965.
- **Controlling the program** by strict management and management techniques.
- **Reporting of technical** and financial status on a continuing basis.
- **Demonstrating a B-70 type** of design.
- **Demonstrating functional** operation of the bombing-navigation system.

Some indication of the first flight date, which the Air Force is still holding under its hat, is the scheduled rollout in September, 1962. This points toward a first flight in the spring of 1963. A General Electric J93-GE-3 engine, six of which will power the prototype B-70s, began tests under altitude conditions in July at the Arnold Engineering Development Center.

Air Force program calls for a total of 520 hr. of flight time to be racked up on the three prototypes. First prototype, which will carry only a two-man crew, will spend 250 hr. in the air on Mach 3 airworthiness, will test handling qualities, exploration of the flight envelope, flutter, vibration and thermal effects, and analyze the propulsion system.

The second prototype, also to be flown with a two-man crew, will spend 160 hr. in the air, checking stability and control over the speed range, obtaining performance data, analyzing thermal effects and checking the performance of the propulsion system.

Third prototype will be the closest to the original planned bomber prototype. It will have the full four-man crew, and they will fly the airplane for a planned 110 hr. Primary concern on these flights will be the Mach 3 environmental conditions and their relation to the performance of the prototype as a weapon system. There will be a complete bombing-navigation system installed in this third vehicle, and it will be completely tested in flight. Weapon separation will be proved also.

In addition, the usual collection of developmental problems will be cranked into the flight-test program as they occur.

C-141/463L

The combination of a modern logistics transport and a materials handling support system is the basic idea behind concurrent development of the Lockheed C-141 and its associate system 463L.

Jointly, the aircraft—which originally was designated as Support System 476L—and the ground-based logistics handling system that goes with it are considered as a total support system. That system is being procured from the start to achieve a national objective: provision of modern cargo carrier plus support system by 1965, for both military and civil use. It is the first such system being procured under Air Force Regulation 80-36, which directs USAF-Federal Aviation Agency coordination to reach the goal.

Lockheed C-141 design calls for a four-turbofan aircraft of conventional design, grossing about 315,000 lb. at takeoff. Mission requirements originally defined in Systems Operational Requirement (SOR) 182 specified a 4,000 naut. mi. range with a 50,000-lb. payload and an alternate mission of 5,500 naut. mi. with 20,000 lb. Takeoff and landing performance, without complex high-lift devices, must permit operation from a 6,000-ft. field as defined by Civil Air Regulations (CAR).

A tight schedule governs development of the plane. The current program calls for a total of 132 aircraft, with rollout of the first programed for July, 1963. First flight is scheduled for December, 1963.

Next four aircraft are scheduled to be available by January, 1964. The first five units then will undergo the various phases of a rigorous flight-test program meeting both military and civil requirements. With FAA certification planned by January, 1965, first planes are expected to become operational by June, just six months later.

As in the other three projects described earlier, the C-141/463L system is being managed by a Systems Program Office under the Deputy for Systems Management. Within this SPO, the aircraft and ground handling system are being handled as separate programs with a common management.

The System Program Director has the usual supporting capabilities in program planning and control, engineering, test, procurement, and production. He also has inputs from other agencies which, having an interest in the program, also have representation in the SPO. These include the Army, Military Air Transport Service, Air Transport Command and FAA.

The usual management tools—PERT, reliability and value analysis—are being used by the SPO in management of the program.

The C-141 layout is simple and quite conventional. A moderately swept (25 deg.) high wing and four podded Pratt & Whitney TF33-P-7 turbofans lift and power a bulky fuselage with an upswept afterbody and a high T-tail.

Cargo compartment is 10 ft. wide and more than nine feet high, matching

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in cross-section the Lockheed C-130 Hercules. But the length is considerably greater—70 ft.—and there is an additional eight feet of cargo space on the retractable ramp which varies in headroom from nine to six feet.

Loading-bed height is 50 in. off the ground when the landing gear is in the normal static position.

Current payload-range curves for the C-141 show the weight-lifting performance to be better than that required by SOR 182. Design payload is 70,000 lb. with a 2.5g load factor. Maximum takeoff gross weight is 315,000 lb.

The C-141 is calculated to be able to carry loads up to 90,000 lb. for short distances if cruise airspeed and altitude are dropped from their normal values of 440 kt. true airspeed and 32,000 ft. cruise altitude.

Interior is very much like the C-130 series. The four-man crew includes pilot, copilot, navigator and systems engineer. For long-time MATS missions, there are two bunks, two crew-rest seats and a galley, all in the flight deck area. Avionics equipment is under the flight deck, accessible in flight. The crew toilet and cargo loading winch are also located below the flight deck, but are reached from the forward end of the cargo compartment.

Plane is fully pressurized from forward of the cockpit aft to the ramp/pressure door. Structure is designed for a 9.3 psi. pressure differential, which means that a sea-level altitude can be maintained up to 23,000 ft. Above that, cabin altitude is allowed to increase to 8,000 ft. up to a maximum altitude of 45,000 ft.

In the closed position, the ramp/pressure door combination acts as the pressure bulkhead closing the aft end of the cargo compartment. This eliminates the pressure loads on the aft fuselage petal doors, and reduces both design and sealing problems. All structure in the pressurized area is fail-safe.

Built-in Jacks

When the ramp/door is lowered, it forms an extension to the cargo floor and serves as a loading platform at truck-bed height. For loading wheeled vehicles, the ramp/door swings down to touch the ground and makes an 11-deg. ramp up to the cargo floor. Loading and unloading operations are aided by stabilizing the cargo compartment through the use of jacks built into the airframe.

The C-141 is being designed to make air drops at speeds up to 200 kt. For this kind of work, the rear fuselage petal doors are used. The upper portion swings out about 14 deg., parallel to the longitudinal axis of the plane. The lower portion of the doors rotates about 50 deg. upward and leaves the rear opening clear for air drops.

The entire cargo compartment floor is designed to a stress of 300 psf., a crushing strength of 750 psi., and a 20,000-lb. single-axle load. Integral rollers can be rotated by hand to give a flat surface if required. There is a cargo-scanning aisle on both sides of the compartment, raised 10 in. above the floor and outside the nine by ten cross-section of the cargo envelope.

Total load is built up on 10 pallets, nine for the main floor and one for the ramp.

Crew entrance door is forward on the left side of the cargo compartment; paratroop doors are on both sides, at the aft end of the compartment. The interior can be easily converted to layouts for troop transport or air evacuation of litter cases. Galley, comfort and oxygen facilities can be pre-palletized and loaded into the interior for these non-cargo configurations.

All subsystems planned for the C-141 are contemporary, not advanced, with development limited to design integration only. But the major philosophy in the choice of subsystems has been to allow for future growth in the provisioning of weight, volume and power so that complex and costly retrofit programs will prove unnecessary.

Design Purpose

The design purpose of System 463L is to develop standardized methods and equipment for an air-cargo handling system that would be completely compatible with surface cargo-handling techniques. Design of the system goes far beyond the usual considerations of cargo handling, reaching back to the terminal area, handling of the stock as it enters the cargo pipeline, in-transit control, and the like. It integrates cargo-handling from source to user, exclusive of packing and crating.

A prototype aerial port of embarkation is being built at Travis AFB now, with service testing scheduled to begin January, 1962. At the Ogden AMA, Utah, Air Force Logistics Command is building a new air-freight terminal building with mechanized equipment, designed with assistance from the 463L program office. Full operation is scheduled for next spring.

Cost analyses of the system show that a saving of $15 per ton can be realized at stations handling 10,000 tons per month cargo. The savings increase as the handling capacity of the station increases. Several terminals of this size are now in being. With Air Force shipping a total of about 11 million tons of cargo per year, possibilities for major savings are evident.

A proposed in-transit control system is planned for development during this fiscal year. It will control the flow of cargo through the system, and provide all necessary data for both terminal operation and statistical reporting. It will be done with a Transportation Accounting Data (TAD) key-punch type of card. Routing, weight, load planning and statistical information can be obtained mechanically with the use of this card system. It could be used to print proper labels, and produce priority, routing, cube and weight data. It could also be used with a proposed shipment planner, which would give load planning data and prepared manifest automatically.

Finally, a third proposed scheme would use the TAD card in a data-integrating machine to give the needed data for load pre-planning, terminal backlog, load following and command statistical reporting.

Cargo Items

The majority of cargo items being shipped overseas weighs 10 lb. or less and takes up one cubic foot of volume or less. You can't get economy by handling many little pieces of this type. So the first logical step is to bunch this collection of bits and pieces by palletizing the cargo.

These pallets are loaded on the rollers in the aircraft with tongues on the pallets fitting into grooves in the restraining rails. The pallet is locked in place with side-rail locks. The design aim is to get an aircraft loaded in 30 min. this way, instead of the three hours taken up by manual loading.

There are two mobile loaders being developed in this program, one for a 40,000-lb. load, and the other for a 25,000-lb. load, and both are usable for all aircraft, not just the C-141. A third piece of mobile equipment—a 40-ft. flatbed trailer with a 30,000-lb. load capacity and adjustable height—has been designed. Two standard forklifts have been redesigned to handle their 10,000- and 6,000-lb. loads on standard pallets, using a lower mast height on the lift. This means they can operate around planes with less chance of punching holes in them.

Conveyors and mechanical sorting devices are used in the terminal area. Cargo is received, processed and marked for sorting on the basis of route and destination. Then it is loaded on standard-sized pallets, moved on a pallet dolly for weighing and securing by nylon webbing, and pulled to the holding area to wait for loading on the aircraft.

This type of handling means that the terminal operation can have maximum capability to pre-plan loads and to avoid peak periods. The method of operation remains the same for all proposed terminal areas; the only differences will be determined by the amount of cargo handled and whether the terminal is a permanent base or a temporary one.

Arnold Validates Systems Early in Design

Former aeronautical facility now stresses space; many government agencies use Center's capability.

Tullahoma, Tenn.—Early validation of future aerospace systems concepts is the major task of Arnold Engineering Development Center.

Originally geared to developmental testing of air-breathing, air-lifted systems with performance at best in the low supersonic regime, AEDC's 19 test cells have made a rapid, effective transition to handle aerospace systems at hypersonic speeds in the rarefied, rigorous environment of future flight.

"We have a four-part mission," explains Maj. Gen. William L. Rogers, AEDC's commander. "The first is basic concept validation, to prove or disprove the designer. The second is development testing, with all that implies. Then after developmental phases, we get fixes to make or bugs to remove. The fourth phase guarantees our future: We keep looking ahead to find out what kind of testing facilities we're going to need at about the time the designers start screaming for them."

Supporting Activity

AEDC is a supporting activity, like any other test or development activity center in the Air Force Systems Command. If Systems Command had been activated a few years ago, AEDC would have been working largely for Aeronautical Systems Division. Even today, a large portion of its work is in support of that organization. But the unusual and huge demands for testing of missile and space systems have changed the program and the work load.

Now, AEDC's work load is about 70% devoted to rocket-powered systems for Ballistic Systems Division or Space Systems Division of AFSC, plus work for National Aeronautics and Space Administration, Advanced Research Projects Agency, the U.S. Army and the U.S. Navy. The remaining 30% represents work on air-breathing systems, but even these are becoming more and more exotic with the passing weeks.

Gen. Rogers' command is sprawled over 41,000 acres of Tennessee's red clay earth. It includes a huge lake—Woods Reservoir—and the termination of four lines from the Tennessee Valley Authority's electrical power supply. From these power sources, AEDC can draw more than half a million horsepower during off-peak periods, up to 165,000 hp. during on-peak times. From the lake, a system of pumping stations and a secondary reservoir gives storage to more than 55 million gal. of water that can be distributed at 250,000 gal. per minute to test sites on the Center.

These test sites are grouped in three major facilities: von Karman Gas Dynamics Facility (vKF), Rocket Test Facility (RTF, formerly called the Engine Test Facility), and the Propulsion Wind Tunnel (PWT). Many individual test stands in the three complexes are unique in the world on the basis of size, capacity or capability.

Operation of these facilities and the actual conducting of the test programs are done by ARO, Inc., contractor to the Center. ARO is a subsidiary of Sverdrup and Parcel, Inc., whose civil engineering capabilities were put to work more than a decade ago on the design, development and construction of AEDC.

The flexibility of the facilities, evidenced by their ability to make the transition from flight in the atmosphere at subsonic speeds to flight in a near-space environment at hypersonic speeds, was no accident of design. One ARO engineer explained that some of his designers didn't even want to worry about the kind of test sections that would be needed in the Center. "They felt the thing to do was to supply a lot of air at one end and a lot of exhauster capacity at the other end of the plant. What went in between would be built up for the specific tests as needed." There is a good argument for this kind of design thinking, but a somewhat more conventional approach prevailed and AEDC gradually took the shape it has today.

To the observer who has been coming to this site for the past 10 years, there is really little basic change in the layout of the Center. The towering exhausters, silvered spheres, and mammoth ducting that surround him at every step look today just as they did when they were first completed. The compressors and exhausters are the same, and make the same horrendous noises as they push and pull air through test cells big enough to hold complete propulsion systems, and in some cases, complete weapons systems. The only change is in the emphasis, in the transition from providing the near-ground environment of the '50s to the near-space environment of the '60s.

ARO, Air Force and Army

New facilities or changes in existing ones are planned by Gen. Rogers' staff; the designs are monitored and controlled by that staff, just as other Systems Command organizations keep watch on the development design of a weapons system. Actual construction starts with a handover of AEDC's plans and specifications to an area office of the U. S. Army Corps of Engineers, which lets the contracts and monitors construction as it progresses.

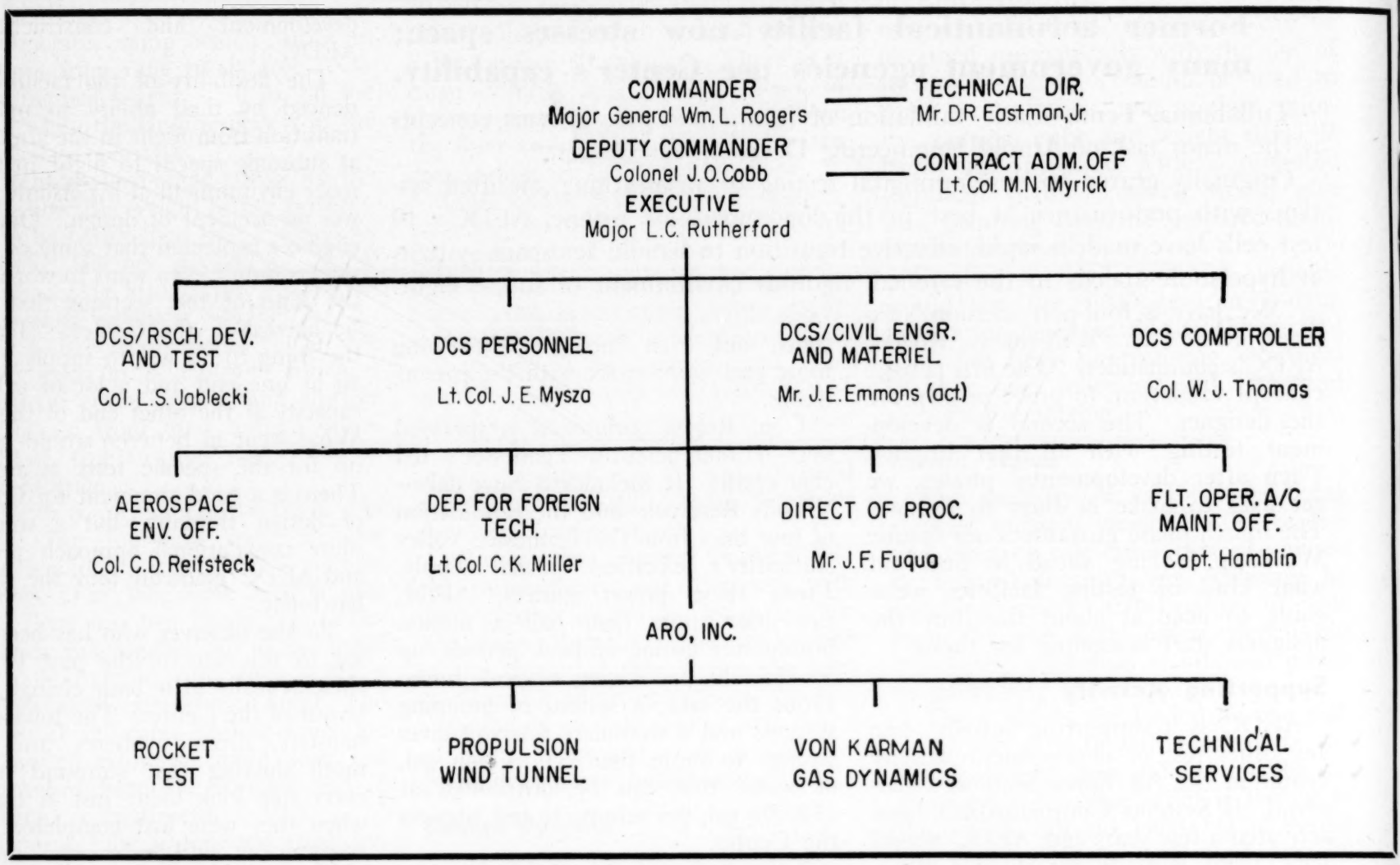
Finally, the finished facilities are accepted as construction-complete by the Army, and as functionally complete by AEDC. They then are turned over to ARO for operation.

ARO's functions extend beyond operation of the test cells to maintenance and administration, and the two principal departments of ARO's organization show that division of effort.

Managing director of ARO is Robert M. Williams, who explained the philosophy of testing. "It all seems to boil down to the question of reliability of

Maj. Gen. William L. Rogers, Commander, Arnold Engineering Development Center, AFSC . . . born Larchwood, Iowa, 1911 . . . graduate U. S. Military Academy, 1934 . . . commander, 346th Engineer General Service Regiment, Germany, 1945 to 1947 . . . transferred to USAF, 1947 . . . duty at Offutt AFB, and Fort Benjamin Harrison . . . Air War College . . . chief of air installations, Directorate of Materiel, MATS, to deputy director, Materiel, 1952 . . . duty with ARDC, 1952 to 1954 . . . assistant for Development Programing, DCS/Development, Hqs. USAF, 1954 to 1958 . . . vice commander, Missile Test Center, Patrick AFB prior to his present position at AEDC.

AEDC Table of Organization



these future systems," he told AVIATION WEEK. "Reliability means that we've got to find out what can go wrong, and that means we've got to have failures. In fact, we believe that the failure to have failures is a failure."

This is not to convey the impression that the mission of AEDC is to break things; testing to destruction is not often a completely satisfactory way to derive answers. But it does emphasize that occasionally something does go wrong; when it does, if the instrumentation is adequate and working at the time, and if the analysis is searching enough, and accompanied by scientific investigation, the results are apt to give more aid to the designer than hundreds of smooth-running tests.

The test programs planned and conducted at AEDC are intended to give the designer useful data for development. They may point out where he has been wrong, or emphasize where he has been right. Out of the myriad of test programs that have been completed by the Center during its useful life, there have been many which used all three major facilities.

Typical of these is the USAF's Discoverer program.

Work on one phase or another of the Discoverer program went on in all three facilities of AEDC. Col. Leon S. Jablecki, deputy chief of staff-operations for the Center, explained that some of the design data for the program had to come from testing under simulated altitude conditions, since there was no good way to extrapolate conventional theory to the limits needed. Jablecki also said that the problems that turned up were not apparent during sea level testing. The implication of this is that without the altitude and environmental capability of AEDC, only flight-testing would have shown up the deficiencies in the system, and that this would have been difficult to analyze and costly.

Jablecki and Harvey M. Cook, assistant to ARO's director of engineering, described these Discoverer problems during a typical flight trajectory.

After separation from the Douglas Thor booster, the Lockheed Agena upper stage of the Discoverer coasts, power-off, in free-fall. The Agena is weightless; before ignition of its Bell rocket engine, the fuel must be seated in the lines and tanks so that gouts of air aren't drawn through the system. Two small ullage rockets, each of 1,000-lb. thrust, are fired to accelerate the vehicle and seat the propellants. These rockets, located near the nozzle of the 15,000-lb. Bell engine, were tested to determine if their exhaust, discharging at high altitudes and ballooning, would damage adjacent nozzle. They did not.

Both Bell engines for Agenas—the 8,500-lb. thrust Agena A engine and the 15,000-lb. thrust Agena B rocket—were tested and retested in ignition, thrust, total impulse, reliability and restart capability under simulated ultra-high altitude conditions.

Best altitude performance of the Agena engine depends on the expansion ratio of the nozzle, the area ratio between the exit and the throat. First-stage nozzles typically have expansion ratios on the order of five to 10; for second stage, this ratio may rise as high as 20; for third stages or for such high-altitude engines as those of the Agena B, the ratio may be above 30, right on up to infinite. But obviously, as the expansion ratio increases, so does the length of the nozzle and that costs weight, which reduces performance. So there is an optimum ratio, where the performace gain obtained by the nozzle is significantly above the performance loss due to the extended skirt's weight.

A graphite extension was first tried, and under tests, failed. The final choice was a molybdenum-reinforced titanium gridded structure with an expansion ratio of 45. Under tests in the RTF, the skirt glowed at yellow heat, but held up for the run.

Spin, despin and positioning rockets of the Agena were also tested in numerous runs at AEDC, to determine ignition reliability and the effects of flame impingement on adjacent structures.

One of the biggst payoffs in testing of the Discoverer followed several unsuc-

HYPERSONIC GLIDER configurations proposed by ASD were tested in the von Karman variable-density supersonic tunnel.

cessful attempts to recover the satellite from orbit. The 1,200-lb. thrust Thiokol retrorocket was installed in the test cells at Arnold, and fired at an altitude of 120,000 ft. After about one-tenth of a second, the entire aft closure failed. Other runs showed separation and burnthroughs in the nozzle that would alter the performance of the rocket. These burnthroughs were caused by impingement of the exhaust gases on the nozzle interior. Two fixes were suggested: beefing up the nozzle wall at the point of impingement, or shortening the nozzle length and changing the impingement angle. Both worked well.

But in addition to fixing the retrorocket, it was also tested at altitude in RTF to evaluate starting, durability of the rocket and nozzle, and to determine the total impulse.

Once the retrorockets have fired and the re-entry cycle of the Discoverer's flight begins, interest centers around the data capsule. The shape of this capsule was determined by General Electric engineers with the aid of AEDC work on the Mark III and IV ballistic nose cone shapes plus parametric studies in PWT and vKF. After GE had designed the shape, the Center tested it in the transonic regime where stability is critical, to establish a stable geometry configuration.

One of these transonic tests was made to determine that the base plate would separate cleanly from the re-entry package itself, instead of being forced against the base by turbulence in the low-pressure wake.

The recovery parachute is deployed at transonic speed and about 50,000 ft altitude. Some drops made from balloons indicated that the chute possibly wasn't functioning properly, so into the 16-ft. transonic circuit of PWT went the whole package, parachute and all. During deployment, the chute remains reefed for four seconds for initial deceleration of the package, and then blossoms fully after explosive cutters release the reefing lines.

Slow-motion cameras were needed to record what happened in the tunnel; the chute was deployed and after a brief period of flailing around, shredded and came apart in the tunnel. The tests proved that a ribbon chute was needed to relieve the initial shock, and that a redesigned main chute would survive both reefed and full deployment.

Minuteman Parallel

Similar examples could be given for the Minuteman program, which turned up in all three facilities. Stability tests of the complete missile were made in the vKF Mach 8 hypersonic tunnel. Both sub-scale and full-scale engines were fired in the Rocket Test Facility; more than 350 engines were tested at altitudes up to more than 150,000 ft. The re-entry vehicle was tested over the aerodynamic range from sea level to about 275,000 ft. and from low subsonic speeds to above Mach 20.

It was concerning AEDC's Discoverer work that Gen. Schriever said a year ago: "If we had not had the facilities here, it might have been a year or longer before we found the answers to some of our problems. The general might have been describing almost any program run through the facilities now, in the past or in the future.

But the past is history, and the biggest concern of AEDC scientists and engineers is the testing to come in the exploration of the future corridor of flight. The kinds of facilities now on hand will have to be joined by new ones to tackle the unusual problems emerging tomorow.

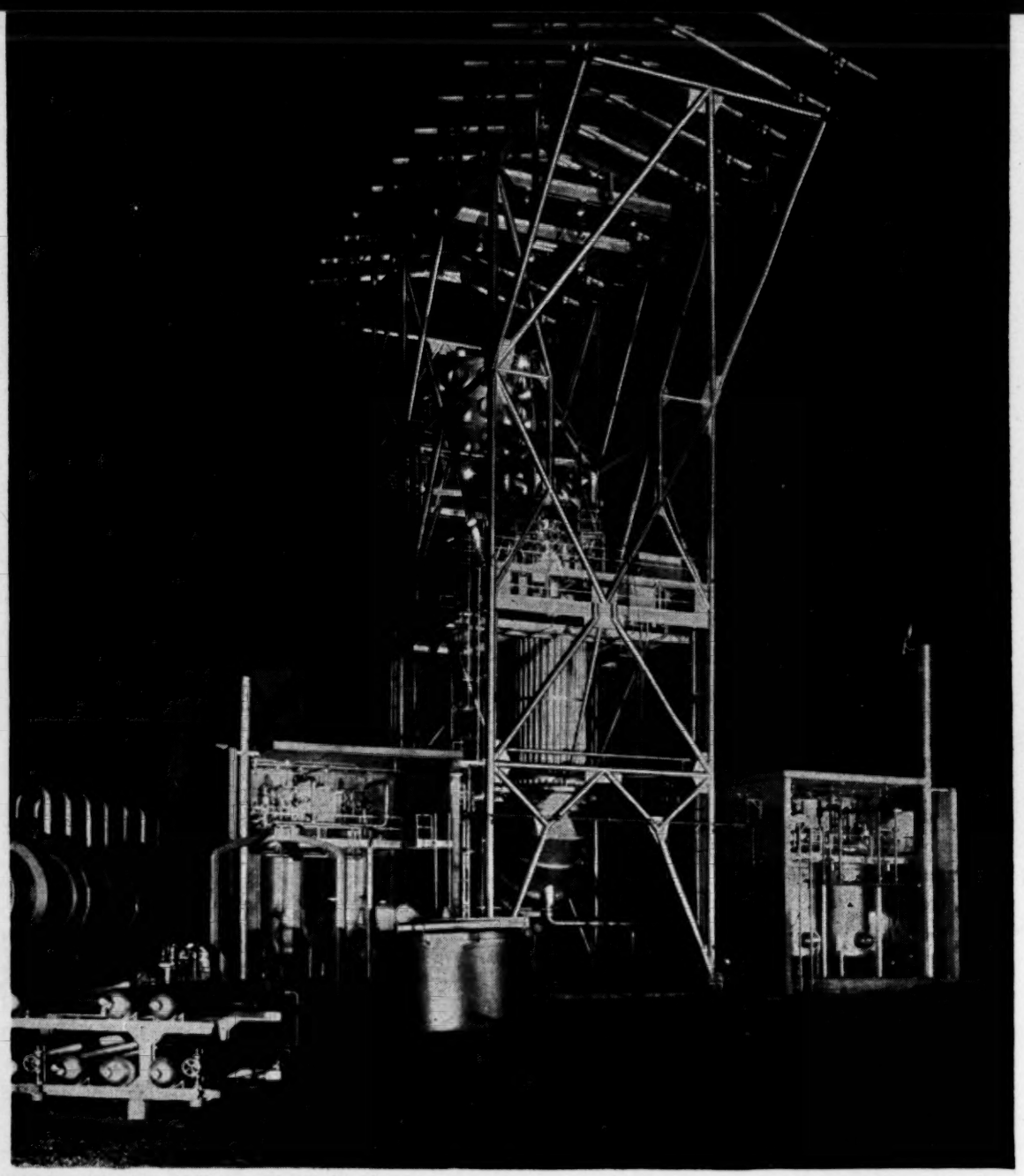
The corridor of flight—that long hallway through altitude and speed ranges from zero to the infinite—is hemmed in on one side by the ability to get lift, and on the other by the ability to withstand high heating input.

Future aerospace systems may operate over vast areas within the confines of the corridor, wallowing near the lifting limits in one phase and skidding near incandescence in another. Other systems may fly along a nearly straight, thin line, just at the beginning of the corridor. Still others may drive far out in a deep penetration of space, slicing through the corridor walls and then back in again at some more remote point.

Each of these systems leaves a trace line in the corridor, a signature of the system which is as much its individual characteristic as the fingerprints of a human. But together, these traces form a network of intertwining lines, with little space between them. If there are enough of these systems, the entire corridor is filled solid with their traces.

Development testing of these systems, a necessary task before the actual flights into the corridor, can only be useful if it duplicates the environment of the corridor. For every point on the trace of an aerospace system, there should be a point in the environmental envelope of a test facility somewhere.

No single testing environment, ex-



TEST STAND J-3 can test liquid or solid engines with thrusts up to 200,000 lb. or flow rates of 675 lb./sec. of propellants.

cept that of the corridor itself, can provide all the duplicating points. Not even a family of facilities can. But the 19 test cells of AEDC come as close to doing the job as possible, and the future facilities now under construction, funded or in planning, will help blanket the area farther out along the now-trackless corridor.

The three classical areas for investigation in aerospace systems are aeromechanics, propulsion and structure. AEDC's Rocket Test Facility is charged with the second of these.

Seven huge test cells, ranging in diameter from 12 to 20 ft. and in length from 16 to 75 ft., plus a bevy of smaller cells and stands, are the bulk of the RTF facility. Designed and planned originally for air-breathing engines, these test units now handle rocket engines as 70% of their work load, with air-breathers relegated to the remaining 30%.

Flow velocities without true temperature simulation can reach about Mach 5 in these facilities; with true stagnation temperature simulation, Mach 4 is about the current limit. Altitude capability is in excess of 100,000 ft.

Net worth of this portion of the AEDC plant is about $75 million. Power consumption varies from 12 to 15 million kilowatt-hours per month. More than one billion gallons of cooling water gush through the cells during a month of testing.

The first rocket engine was fired on June 8, 1958, breaking into the 100% air-breathing engines work schedule for the first time. Since then, more than 1,350 individual rocket firings have been made, and almost one-third of these have been for the Minuteman program.

Workhorse of the rocket-firing program is Cell T-3. Converted within six months of establishment of the requirement, T-3 held its first rocket firing in February, 1959. To date, more than 500 runs have been made using solid, liquid and gaseous propellants in sub-scale and full-size tests. On Minuteman alone, about 300 sub-scale runs were made to evaluate propellants and nozzles for the three stages. Polaris, Atlas-Able, Saturn, Discoverer and Mercury programs were also supported by development testing in Cell T-3.

Capability of the cell has been increased above that of the others by the use of a chilled-water cooling system and a second steam injector in tandem with the existing one. Altitude capacity increased to 150,000 ft.

Normal altitude capability of the other test cells is furnished by the plant's exhausters, which can drop the environmental pressure in the cell to altitude levels of 90,000 ft. (There was a time when this kind of altitude capability was regarded as ridiculous by critics of AEDC).

In series with the exhauster plant is a tailored diffuser-ejector combination which offers another 40,000 ft. of altitude simulation. During the firing of a rocket engine in the cell, the engine itself pumps in the diffuser and maintains test altitude simulation. During thrust tailoff at the end of the firing cycle, more steam is pumped into the diffuser to maintain altitude until complete shutdown.

RTF Programs

The four T-cells and two J-cells of the RTF have run through a wide variety of test programs of which these are typical:

- **Pratt & Whitney J75 engine** as installed in the Convair F-106 and Republic F-105. Much of the F-106 inlet system was included in one series of tests on the engine. Program scope included determination of combustion efficiency, blowout and re-ignition limits, inlet distortion and component reliability.
- **Pratt & Whitney TF33** turbofan engine for the Boeing B-52H program. These supporting tests were made to verify in-flight thrust calculations and to find specific fuel consumption with a special fuel. Range of the tests was from sea level static to 55,000 ft. and about Mach 0.9.
- **General Electric J93-GE-3** turbojet programed for the North American B-70. This engine was installed recently and its first test run was made July 20. Program will cover a 15-month time period in Cell J-1.
- **Thiokol XLR-99 rocket engine** for the North American Aviation X-15 research airplane. This engine, rated at 50,000-lb. sea level static thrust, was cycled through 25 high-altitude ignitions, cutoffs and re-ignitions. Simulated fuel-line ruptures were included in the test program to check out safety systems on the engine.
- **Saturn booster base-heating.** Configurations of turbine exhaust ducts in the base of the eight-engine Saturn space booster were tested to determine their effects on base heating from recirculation of the exhaust gases. Test runs were made with a 1/20-scale model in a T-cell, over the range of speeds from Mach 0.8 to Mach 3, and altitudes from 11,000 ft. to 80,000 ft.
- **Aerojet-General XLR-91-AJ5** liquid-rocket engine for Titan II. This engine, recently installed in the new Satellite Test Cell (J-3), will be tested to determine performance and durabil-

AEDC Test Facility Status as of Aug. 1961

FACILITY	SIZE	MACH RANGE	APPROXIMATE ALTITUDE RANGE (Ft)	CURRENT STATUS
ROCKET TEST FACILITY - For Development Testing of: (1) Turbojets (2) Ramjets (3) Rockets (4) Turbofans (5) Base Flow Studies of Models of Ballistic Missiles and Spacecraft				
Test Cell T-1	12-1/2' D	0 to 3.0	S/L to 100,000	In Operation
Test Cell T-2	12-1/2' D	0 to 3.0	S/L to 90,000	"
Test Cell T-3	12-1/2' D	Altitude only	S/L to 130,000	"
Test Cell T-4	12-1/2' D	0 to 3.0	S/L to 130,000	"
Test Area T-5A	6" x 6"	0 to 4.0	S/L to 100,000	"
Test Cell T-5B	5' D	0 to 3.0	S/L to 90,000	"
Test Cell T-5C	5' D	0 to 3.0	S/L to 90,000	"
Test Cell J-1	16' D	0 to 3.3	S/L to 100,000	In Operation
Test Cell J-2	20' D	0 to 3.3	S/L to 100,000	"
Test Cell J-3	14' D	Altitude only	S/L to 130,000	"
Test Cell J-4	90' D	" "	S/L to 130,000	In Construction
VON KARMAN GAS DYNAMICS FACILITY - For R & D Testing of Scale Models: (1) Aircraft (2) Missiles (3) Spacecraft (4) Re-entry Devices				
Tunnel A	40" x 40"	1.5 to 6.0	10,000 to 150,000	In Operation
Tunnel B	50" D	8.0	120,000 to 180,000	"
Tunnel C	50" D	10.0 & 12.0	120,000 to 180,000	"
Tunnel E-1	12" x 12"	1.5 to 5.0	S/L to 33,000	In Operation
Tunnel E-2	12" x 12"	5.0 to 7.0	S/L to 180,000	"
Tunnel - Hotshot I	16" D	12.0 to 20.0	100,000 to 250,000	"
Tunnel - Hotshot II	48" D	12.0 to 20.0	100,000 to 250,000	"
Tunnel F	100" D	10.0 to 25.0	100,000 to 500,000	In Construction
Hypervelocity Range	10' D x (1,000' long)	5.0 to Escape Velocity	S/L to 300,000	"
PROPULSION WIND TUNNEL - For Development Testing of: (1) Full Scale Propulsion Units (2) Very Large Models with Scaled Propulsion Units (3) Large Aerodynamic Models (4) Research				
Transonic Leg	16' x 16'	0.6 to 1.6	S/L to 100,000	Closed; breakdown
Supersonic Leg	16' x 16'	1.4 to 4.5 **	25,000 to 160,000	In Operation
Transonic Model Tunnel	12" x 12"	0.6 to 1.6	S/L to 25,000	"
Supersonic Model Tunnel	12" x 12"	1.4 to 5.0	12,000 to 210,000	"
MARK I - For Development Testing of Space Capsules				
Aerospace Systems Environmental Chamber	30' D x (70' long)	Altitude only	S/L to 250 miles	In Design
7' Vacuum Chamber - For Research and Training	7' D x 12' long	Altitude only	S/L to 250 miles	In Operation

NOTES: * 300,000 foot Altitude Capability by February 1961
** Proposed to go to Mach 8 in FY 1962 MCP

ity of an ablative skirt. The AJ5 model of the Aerojet engine is rated at 100,000 lb. thrust and burns Aerozine as fuel in nitrogen tetroxide.

• **Aerojet-General solid-propellant** second-stage engine for Minuteman. This is the largest solid motor fired in the RTF, and its tests were part of development testing for the Minuteman which included more than 400 firings of full-scale and sub-scale motors and nozzles for evaluation of performance and base heating on all stages of the missile. These firings in Cell J-2 will include an additional 45 full-scale tests on both second and third stage engines before the end of next year.

J-2, which is the largest horizontal test cell, and J-3, the Satellite Test Cell, are being modified further to increase their altitude capability and ability to simulate space environments.

Cell J-2 is being modified to simulate a solar and orbital environment for large satellite rocket engines. Solar radiation will be simulated by infrared heating lamps with an output of about 1,400 Btu. per square meter. Altitude capacity will be increased largely through the use of a cryogenically cooled liner, 18 ft. in diameter and 32 ft. long, placed in the exhaust ducting. Temperatures will drop to as low as −320F and simulated altitude will rise to 350,000 ft. A test engine can be cold-soaked or subjected to solar radiation, and then checked for its ability to light and relight.

Cell J-3 currently has an altitude capability of about 100,000 ft., and a thrust capacity of about 200,000 lb. The aim of the modification program

for the cell is to increase altitude capability and at the same time, simulate other space environments, as in the case of Cell J-2.

Modification will be essentially the same as in the J-2. A cryogenic liner in the large tank will simulate space temperature, and permit cold-soaking the engine before firing. A solar simulator will add the input of the sun's radiant energy. Cryopumping facilities will drop the chamber pressure altitude to more than 250,000 ft. During a firing, a special system at the nozzle will pump out exhaust gases to maintain an altitude simulation of approximately 200,000 ft.

Propulsion Wind Tunnel

Two circuits—one transonic and the other supersonic—with test sections 16 ft. square by 40 ft. long made up this facility until the beginning of August. Then, during a run at one-third power in the transonic circuit, one of the compressor disks failed partially and blade after blade ripped, folded or failed. The transonic circuit will be out of action for a period of time now estimated at two years.

Tests scheduled for the transonic circuit have either been canceled or rescheduled at another facility. Repairs to the tunnel will probably cost about $2 million, according to one early estimate.

Major jobs assigned to the PWT facility center around aerodynamic testing of final configurations, or in some cases, of the development item itself with the complete propulsion system either operating or simulated.

Capabilities of the two circuits generally matched those of the engine test cells; maximum test speed in the supersonic circuit is about Mach 4, and maximum altitude simulation is about 180,000 ft. With some modification, the supersonic circuit could be run up to Mach 8.

Two major technical features—perforated test section walls and scavenging systems—contribute to the correct simulation of full-scale performance. The perforated walls, made of plates each about two by eight feet and opened with ¾-in. dia. holes, are drilled at a slant angle of 60 deg. Near Mach 1, the holes keep the test section unchoked, just like the earlier slotted-throat or perforated-wall tunnels of the NACA or Cornell Aeronautical Laboratory. At supersonic Mach numbers, the holes cancel the disturbance waves from the model so that reflected waves do not impinge on the model itself and nullify the test.

The scavenging system removes the products of combustion from the operating propulsion system to avoid contamination of the primary test air stream.

Capability of this system means that some full-scale propulsion systems can be operated in the tunnel, and that other systems can be simulated, either by cold flow of air, scaled liquid-propellant rocket engines using RP-1 and liquid oxygen, or scaled solid-propellant rockets.

Quail Decoy

McDonnell's GAM-72A Quail decoy missile furnished a good example of tests made with an actual developmental vehicle with its own propulsion system operating during the runs. The complete Quail was mounted in the tunnel, and its General Electric J85 jet engine was fired and run for a series of tests evaluating the aerodynamic and propulsive performance.

The combined Dyna-Soar/Titan II vehicle is an example of model tests using scaled liquid-propellant rocket engines for duplication of the firings of the Titan booster engines. The one-tenth-scale of the glider-booster combination was being tested toward the end of July this year, in a series of hot runs at selected points along the flight path to accumulate a variety of data.

On the evening of July 20, a group of Aviation Week editors was present in the control room for two hot runs out of several scheduled for that night. Purpose of the specific tests was to get data on the force required to gimbal the engines in the Titan II for trajectory control.

The test runs resembled in many ways an actual firing of a large-size missile. There was a preliminary check of model, instrumentation and tunnel conditions; there was a countdown, and the engines were fired. After 45 sec. of running and data-taking, the engines were shut down. Within minutes, test conditions had been changed for the next run. Using this coordinated technique, engineers in the PWT have been able to plan as many as 17 runs in a single night.

Other Programs

Other programs in PWT included:

- **Lockheed Polaris,** Navy fleet ballistic missile, tested in one-fifth scale model form. Program investigated recirculation of the jet exhaust, base heating rates, jetevator effectiveness, and base skirt design. Firings were hot.
- **Aerodynamic tests** on full-scale Army Sergeant ballistic missile and Air Force GAM-72A Quail, and aeroelastic tests on the Boeing Bomarc B. Scale-model tests established the aerodynamic characteristics of Army's Redstone missile.
- **Hot firings of models** of the Martin Titan and NASA's Saturn space booster.
- **Aerodynamic characteristics** of a one-third scale model of the Mercury capsule and escape tower.

This gas dynamics testing system

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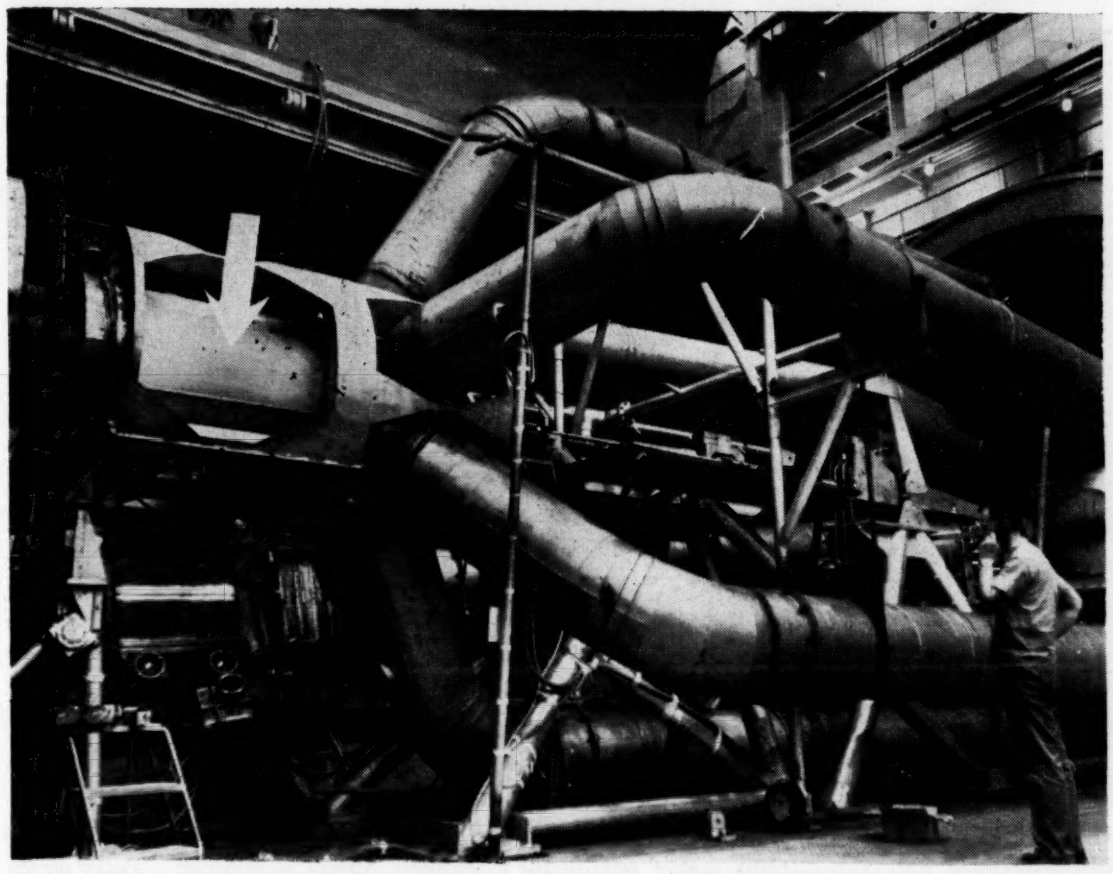


FULL-SCALE third-stage solid-propellant rocket engine for Minuteman was tested in Rocket Test Facility for characteristics at thrust termination. Ignition at altitude and retro impulse were to test goals. Blowout ports near motor head were ducted to exhaust circuit.

works to help determine shape, structure and performance of vehicles for the outer reaches of the flight corridor. Almost any weapon system conceived during the past decade has been through aerodynamic testing in the tunnels of vKF.

They have been blasted with air from Mach numbers of 1.5 to 20, at simulated altitudes from 50,000 to 200,000 ft. They have been tested in model form or in full-size layout in test sections with from 12 in. to 100 in. dia.

Their names include the top programs for the three services and NASA: Redstone and Nike Zeus, Atlas, Minuteman and Dyna-Soar, Polaris, Mercury and the X-15.

Coupled with this versatile capability, which can handle a wide variety of tests and test subjects, the vKF has unique capabilities which account for major test programs. Last year, for example, much of the tunnel work was aimed at investigating the aerodynamic characteristics of hypersonic lifting vehicles. In all, 28 different models of winged hypersonic gliders were run through two of the tunnels. Results of the tests were correlated with a theoretical study made outside AEDC for the Air Force and aimed at determining load distributions, stability and control characteristics. The families of vehicles tested had variations in physical parameters; leading edge radius, sweepback angle, thickness ratio, wing section and body profile were altered and studied.

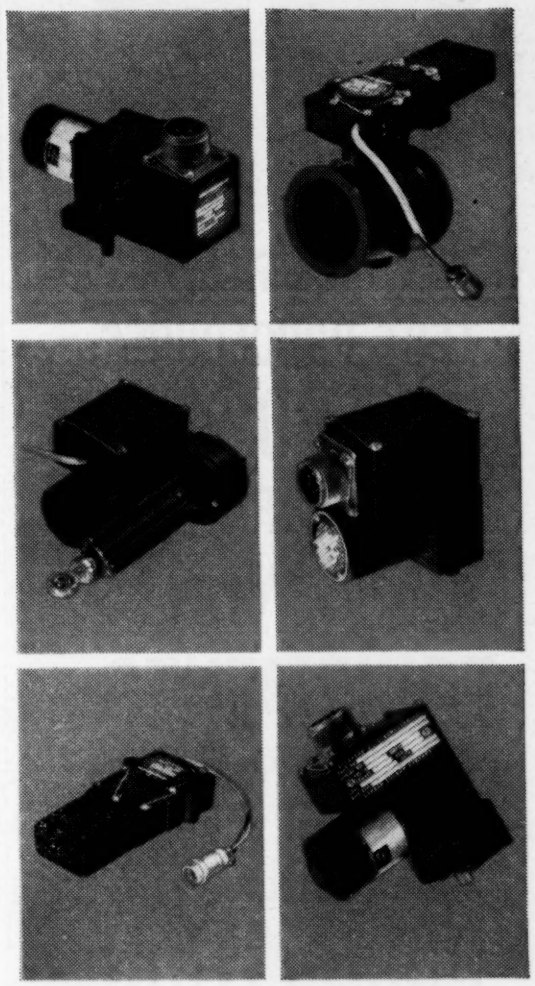
Doing this kind of work requires two types of facilities. One is geared to the developmental tasks which produce finished reports on portions of or complete systems. The other is aimed at increasing the capability and the knowledge of the Center. The 11 tunnels and ranges of the von Karman Facility are considered, therefore, in two classes: Development and Research units.

Development category has seven wind tunnels. Two of them, E-1 and A, are supersonic, with variable Mach number nozzles. E-1 was the first tunnel to become operative in the Center back in 1953. It has a test section 12 in. square, and operates over the speed range from Mach 1.5 to 5.0. Tunnel A is the large, variable-density tunnel with a 40-in. square test section and a Mach number range between 1.5 and 6.0.

Tunnel A, the largest in existence with a variable nozzle, has handled some unusual programs. In addition to the family of hypersonic gliders referred to earlier in this article, the tunnel also ran tests on a small scale model of the Atlas missile base with operating engines. Other programs included force tests of a tiny data capsule positioned along its escape trajectory from a small model of the Jupiter missile; drag variation data of a decleration device in the wake of a model representing its mother vehicle; and acoustic response tests to determine sound levels, frequencies and pressures of a variable-geometry cavity.

Three tunnels are now operating in the hypersonic flow regime: Tunnel E-2, a 12-in. intermittent type calibrated from Mach 5, 6, 7 and 8; Tunnel B, a continuous flow Mach 8 tunnel, the largest in existence; Tunnel C, similar to B, but with a speed capability up to Mach 10, eventually to

New family of compact Barber-Colman actuators helps solve critical space and weight problems



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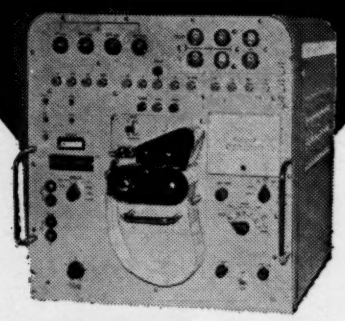

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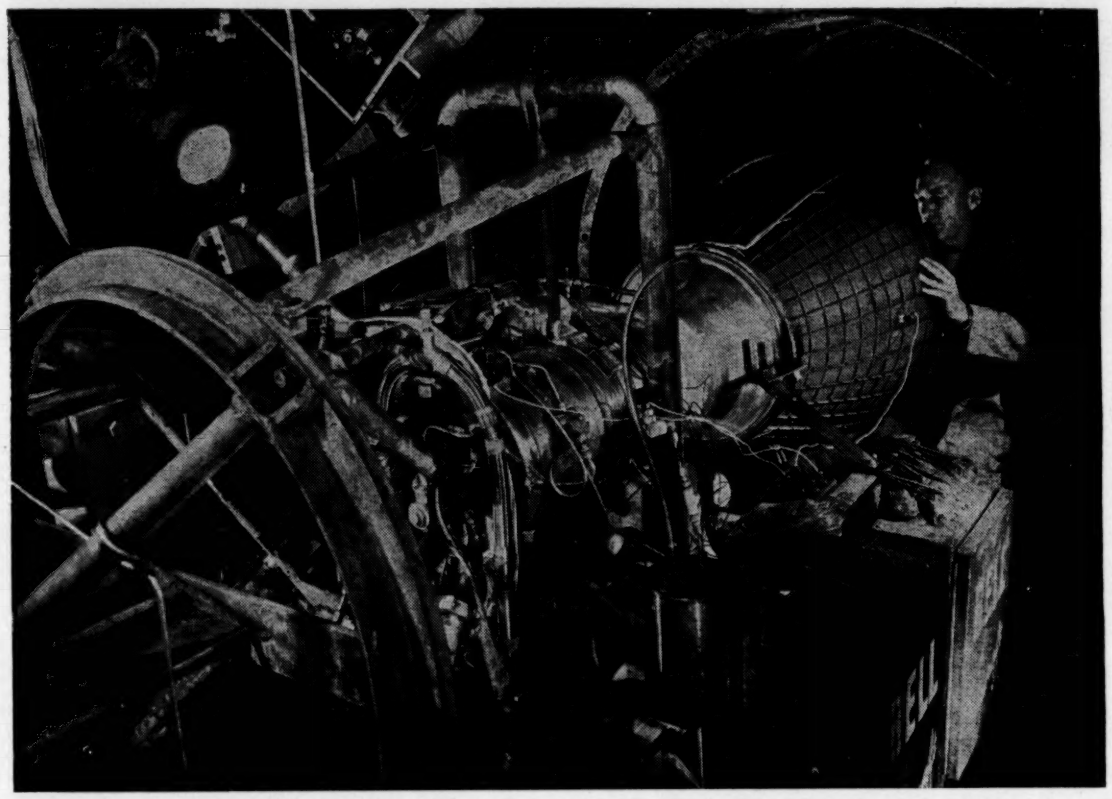

RESTART CAPABILITY and durability of titanium-grid nozzle skirt were two items proved during tests of Bell Aerosystems rocket engine for Lockheed Agena B vehicle. Tests were performed in engine cell of RTF at simulated altitudes above 100,000 ft.

be increased to 12. Both the latter tunnels are completely water-jacketed, and can therefore operate at high temperatures. Both these tunnels are geared to heat-transfer work, including work on transient heating of nose cones and re-entry vehicles.

The final two developmental tunnels, soon to be joined by a third and larger one of the same type, are the so-called Hotshot tunnels, arc-driven wind tunnels with large real velocities and temperatures combined with high Mach numbers.

Hotshot 1, a developmental tunnel for the type, has a 16-in. dia. test section. It operates over the Mach number range from 16 to 21 using nitrogen as the working fluid.

Hotshot 2 is a 50-in. dia. tunnel working in the same speed range as Hotshot 1. Both of these tunnels, because of their specialized capability, combining real velocities and temperatures with high Mach numbers, have been used in the study of re-entry shapes and nose cones, plus configuration work on space capsules and vehicles, including the Mercury capsule.

Research Facilities

One ballistic range, two impact ranges and a low-density tunnel compose the current roster of research facilities available at AEDC. The primary purpose of these facilities is to study their applications to development problems, to the perfecting of better instrumentation and to data-taking techniques.

Four guns—a 40-mm. cold gas type, a 40-mm. combustion-driven type, a 13-mm. two-stage gun and a 20-mm. arc-driven gun—are used to launch projectiles down the first of these research facilities, the Hypervelocity Pilot Range. This unit, six feet in diameter and 103 ft. long, simulates the altitude environment from sea level to 300,000 ft. The first two guns are used for firing telemetry models up to speeds of about 12,000 fps. The two-stage gun has successfully fired a one-gram model at a speed of 26,000 fps. The arc-driven gun is a development unit to achieve higher speeds.

Primary mission of the HPR is to develop techniques for firing models at enormous speeds and to evaluate data-gathering systems, both missions aimed at providing background for the design and operation of the full-scale 1,000-ft. long Range G now under construction.

One of the most interesting sidelights in the Center is the development work in subminiature radio transmitters, small enough to be carried in the tiny projectiles, and rugged enough to work during high accelerations. These accelerations reach values of up to 560,000g without a transducer element aboard, or on the order of 225,000g if there is a transducer.

Two hypervelocity impact ranges were transferred earlier this year from the Air Proving Ground Center at Eglin AFB, Fla., to AEDC. Both these facilities are used to study impact of projectiles at speeds up to 20,000 fps. Both use light-gas guns of the type developed by the Naval Research Laboratory.

Final research tool is a low-density hypervelocity tunnel, built to provide information on the ways to simulate high-speed flight at altitudes between

40 to 60 mi. Because of the low-density environment, the tunnel can be operated continuously for several hours at high stagnation temperatures.

Expansion at AEDC is geared to the exacting requirements of even higher and faster flight in the corridor. Modifications to existing facilities, such as Cells J-2 and J-3, will provide part of the answers to the questions of the future. But detailed answers will demand detailed studies, possible only in new kinds of facilities, or test units with great increases in capability, such as this typical array:

• **Range G: 1,000-ft. hypervelocity** range. A two-stage light-gas gun will fire projectiles into a 1,000-ft. long, 10-ft. dia. tank which can be evacuated down to an equivalent pressure altitude of 250,000 ft. Velocities will be on the order of those found in re-entry of long-range ballistic missiles or satellites in orbit. Observation of the flight path and the flow field around the model, to be accomplished by photo-optical and telemetry systems, will furnish data on aerodynamic loads and physical properties of the flow field. If needed, the range can be extended to 5,000 ft. in the future. Completion is scheduled for July 1962.

• **J-4 Rocket Altitude Cell.** This underground test facility will be built around an evacuated chamber 100 ft. in diameter and 250 ft. deep. Thrust capacity of the unit will be 500,000 lb. to start, with design capability for an increase to 1.5 million lb. Altitude simulation will approximate 100,000 ft., depending on the size of the rocket. Completion is targeted for 1963.

• **Aerospace Research Chamber.** This test unit was developed to obtain design criteria for larger facilities and to train personnel in the techniques of operating and using such facilities. Working space is seven feet in diameter by 12 ft. long. Currently operating in an initial phase, the highest simulated altitude so far has been about 375 mi. As a comparison, the interior atmosphere of a conventional vacuum tube is about 5,000 times as dense.

• **Mark I Aerospace Environmental Chamber.** Object of this test facility is to provide space environment from the ground to 300 mi. up, including pressure, heat sink, solar radiation, albedo and planet radiation, and launch and orbital vibration. Diameter of the chamber is about 35 ft., and its height is 70 ft., making it large enough to take such full-scale vehicles as the Lockheed Agena and subject them to orbital environment under dynamic conditions with the subsystems operating. Completion is now scheduled for the latter part of 1962.

But these test systems will solve the problems only of the near future; there will be further needs for more complex testing. For example, the corridor of flight is covered largely by short-duration test devices, such as the Hotshot tunnels or the hypervelocity ranges. Continuously running wind tunnels hardly make a dent in the low-speed, low-altitude end of the corridor.

As operational altitudes increase, the growth of system upper stages will reflect that increase. This requires the capacity to handle more thrust at higher simulated altitudes in propulsion test cells. Hypersonic air-breathing engines will demand new techniques. Space propulsion, with its roots already firmly planted in the fertile soil of electric propulsion, will require an environment now unfamiliar to AEDC.

Space environments mean more than reduced pressures and solar radiation. They will feature solar storms, meteorite showers, energetic particles, magnetic and electrical fields, and reduced gravity. How can these be simulated on the ground?

Currently, only the direction of the thinking is known. It is straight ahead. It is aimed at the future development of testing systems that will continue to perform the kind of mission that AEDC is doing now.

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Edwards Becomes Space Recovery Center

Capability developed by Edwards AFB for recovery of the X-15 may be expanded to include Dyna-Soar.

Edwards AFB, Calif.—Air Force Flight Test Center, site of historic milestones in aviation progress, is broadening its scope to become the first USAF Space Recovery Center.

Official directives have not yet been issued designating Edwards AFB as such but the capability developed for the X-15 and being expanded for recovery of the boost-glide Dyna-Soar provides the foundation from which to extend the activity into a Space Recovery Center.

Proximity to the 65 sq. mi. dry lake bed with its 13-mi. long landing strip is not the only reason Edwards is well suited for recovering maneuverable space vehicles.

The proximity to the West Coast and the distinguishing prominence of the Baja California peninsula permits the 301,209-acre site to be accurately pinpointed as to location from miles in space. This will hold true for both equatorial as well as polar orbiting manned spacecraft.

The extent of the activity Edwards AFB will see in recovering maneuvering, orbital craft will of course, depend on the success of such vehicles, the first of which will be Dyna-Soar. Judging from the successful recovery of many X-15 flights on the Rogers dry lake bed, the technique of which will be expanded and applied to Dyna-Soar and other spacecraft, personnel and facilities at Edwards are well equipped to handle a space vehicle recovery role.

Testing Preparation

Preparations for testing manned spacecraft occupy more and more of the total manpower at AFFTC and this will build gradually to the day of the first orbital recovery when virtually every single person on the base will be directly or indirectly working on the operation. Until then, work still remains on present weapon systems and research projects in support of the Aeronautical Systems Division at Wright-Patterson AFB, Ohio.

About 77% of the projects at AFFTC, or 83 out of 138 projects, are being conducted for and at the direction of Aeronautical Systems Division. Thirteen other projects are being conducted for other research and development bases. Electronic Systems Division has seven projects in process, Space Systems Division has three, and one each is being conducted for the Air Force Missile Development Center, Air Force Special Weapons Center and the Air Force Systems Command. The remaining 42 projects are AFFTC-generated to increase the Center's capability to support other projects.

The work load varies according to operational requirements and the capability must be maintained to support programs which may arise suddenly. One example is the current program on an external tank configuration for the F-100. Operational necessity dictates a need for the tanks and it is up to the AFFTC to flight test the airframe and tank configuration to see that it is feasible from an operating and safety standpoint.

Some of the programs involve new aircraft such as the Boeing B-52H bomber which now is undergoing a complete test program. The Northrop T-38 Talon is engaged in seven separate test programs, the Convair B-58 Hustler in nine. Considerable work remains to complete runway barrier engagement test on service aircraft, among them the B-58 and the T-38. Until recently, Edwards supported testing of commercial jet transports by providing use of the ground tracking and telemetry network as well as providing chase aircraft which are vital from the safety standpoint during almost all testing. This more or less routine test flying and engineering effort is expected to continue for some years because new operational requirements are being generated almost daily for existing aircraft and these must be proved or disproved by Edwards personnel.

Brig. Gen. Irving L. Branch, Commander, Air Force Flight Test Center . . . born Keokuk, Iowa, 1912 . . . BS degree civil engineering Norwich University, 1934 . . . received his wings, 1935 . . . commanded 1st Bombardment Group, Chinese Air Force, 1943 . . . deputy commander 72nd Fighter Wing, Colorado Springs . . . Armed Forces Staff College, 1947 . . . duties with United Nations . . . Air War College, 1953 . . . duties with Armed Forces Special Weapons Project as Chief of Staff, 1957 . . . deputy commander, Air Force Special Weapons Center, 1957 . . . decorations include Air Medal, Distinguished Flying Cross, Legion of Merit, Yun-Hui (Chinese), Chinese Wings.

X-15 Progress

Progress in frequent test flights of the three X-15s operating out of the National Aeronautics and Space Administration's High Speed Research Station is carefully watched by AFFTC pilots and engineers working on Dyna-Soar.

The joint NASA/USAF/Navy X-15 program which consumes a large part of AFFTC manpower brings Edwards AFB virtually to a standstill when one of the three rocket-powered research craft is in the air. Numerous support and chase aircraft are airborne, rescue helicopters are at ready and communications, tracking and telemetry facilities are devoted exclusively to the recovery of the craft and the acquisition of data.

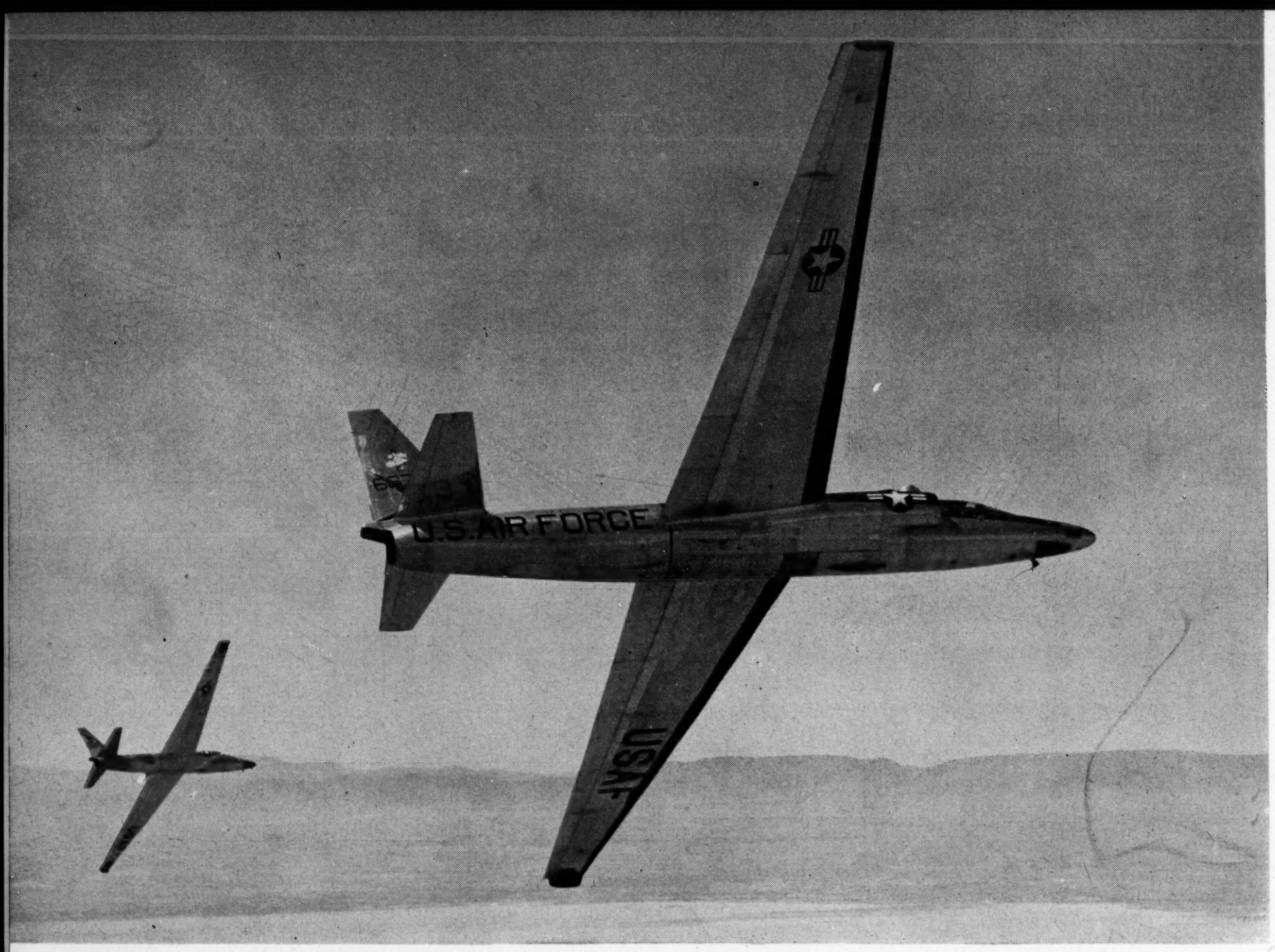
X-15 pilots and engineers have pushed the design envelope of the X-15 very close to the ultimate limit. However, the full performance envelope of the aircraft extends to a velocity of Mach 6.5 and to the true-ballistic altitude of 600,000 ft. Much of the X-15 flying to date has been of a preliminary nature and the program now is beginning in earnest by exploring high angle of attack flight on the fringe of space. The delicate task of controlling the aircraft's attitude within a narrow angle of attack corridor while it "mushes" back into the atmosphere is one of the most exacting requirements ever laid down for a test pilot.

Program Objectives

Objectives in the X-15 program are the investigation of aerodynamic and structural heating, aerodynamic loads and structural research, flight control development, lift versus drag characteristics, recovery and landing techniques, aero-medical research and operational evaluation.

Even though temperatures upwards of 600F have been experienced in the

RAF VULCAN B MK.2 AND USAF B-52H OVER EDWARDS AFB.



LOCKHEED U-2 RECONNAISSANCE AIRCRAFT

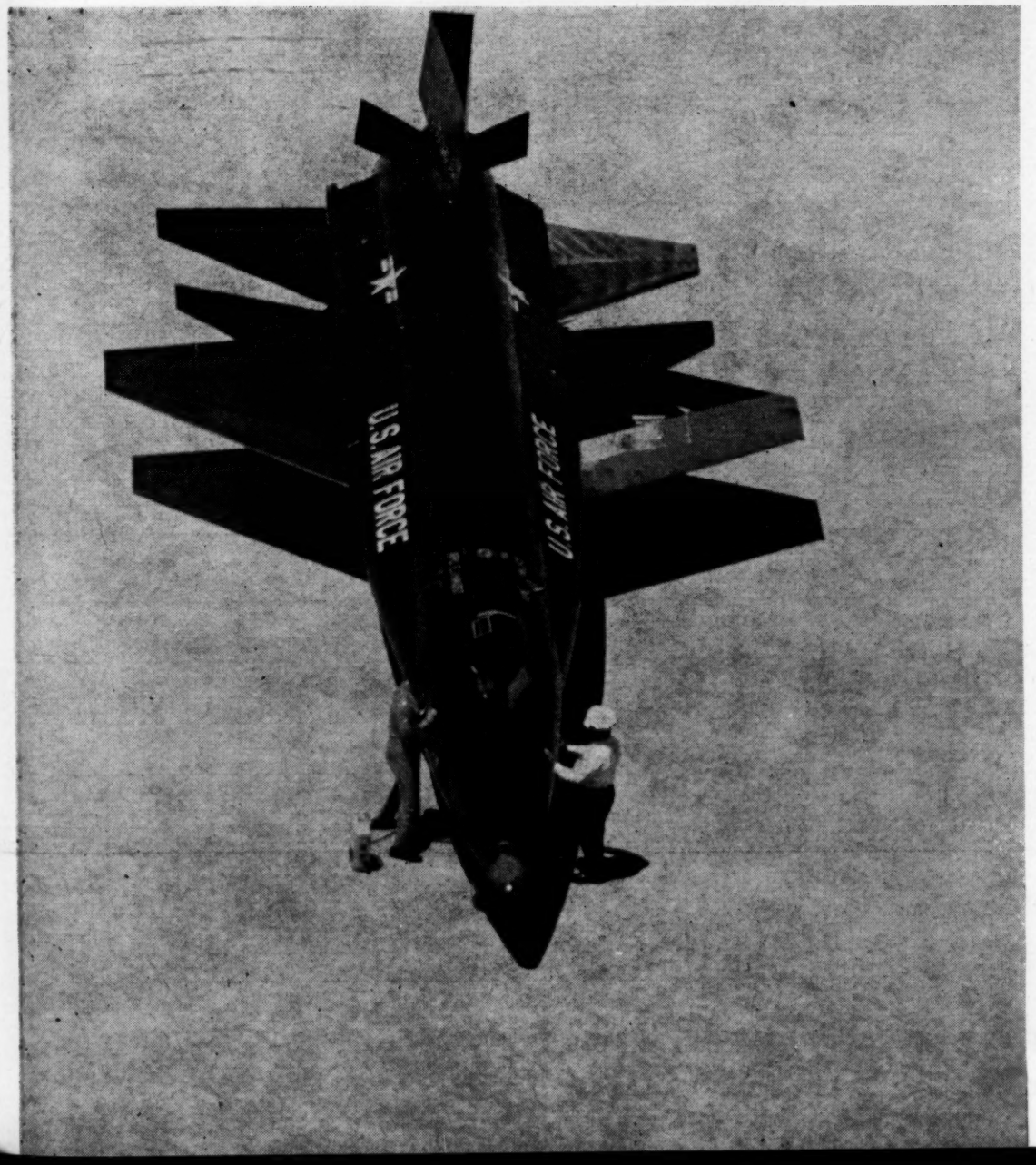
X-15 in establishing recent speed and altitude records, temperatures up to 1,200F have been designed for and will be approached during forthcoming reentry tests. Development of reaction and aerodynamic controls already has progressed from initial flights. Refinements have been made to the sidestick control for the aerodynamic portion of the flight and the rocket-powered reaction controls for out-of-atmosphere flight are being refined. Previous data reveals that control of the neutrally-stable machine in out-of-atmosphere flight is possible with present reaction controls although a very demanding and exacting task. Considerable relief from this chore is expected from the installation of stability augmentation in the reaction control system which then will demand less pilot attention in maintaining a precise attitude.

Recovery Techniques

Recovery and landing techniques are becoming increasingly more refined each flight. Experience in energy management, defined as the expenditure of the combination of altitude and airspeed inherent in the craft as it is in the air, has enabled X-15 pilots to consistently land on the dry lake bed within 1,000 ft. of a predetermined point despite the complete absence of power during descent and landing. Considerable reliance on backup information is placed by the pilot of the X-15 in the determination of his position in space and airspeed throughout the flight. Lines of various airspeed and altitude limits are overlaid on a map of the high range so that ground observers can advise the pilot if it becomes apparent that he might maneuver in such a way as to be unable to return to base. The unusual L/D characteristics of the craft are such that it could be over the base at extreme altitude at a speed of Mach

U-2 ALSO CARRIES INFRARED DETECTORS IN BLISTER BEHIND COCKPIT

X-15 RESEARCH AIRCRAFT ON B-52 CARRIER (ABOVE) AND ON GROUND AT EDWARDS AFB



5 and be unable to land on the dry lake if energy management was used incorrectly. The potential and kinetic energy of the machine must be carefully expended to effect a safe recovery. Of definite advantage will be a useful cockpit display depicting proper methods of energy management. It is expected that such an instrument or instruments will be an outgrowth of the X-15 program.

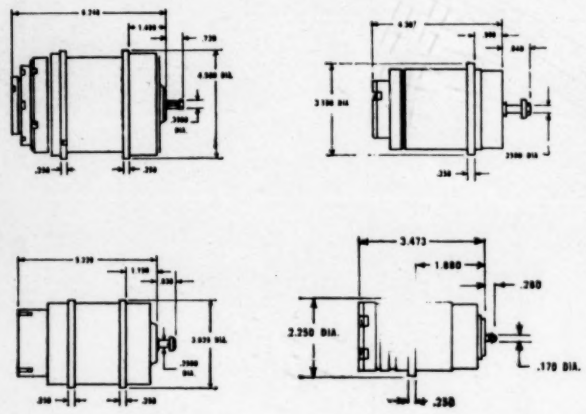
Aeromedical Data

Aeromedical data which is invaluable to the science of bioastronautics for space flight is being gathered in quantity on each X-15 flight from special instrumentation packs attached to the pilot's body. This has allowed the acquisition of quantitative measurements of pulse rate, respiration rate and body temperature.

Initially, flight surgeons were alarmed to discover that the pilot's pulse rate at times climbed to rates which under ordinary circumstances would have been debilitating. Critical portions of the flight such as immediately prior to launch, at engine lightoff and burnout, at the initiation of letdown, and at landing, saw the pulse rate rise to as much as 180 per minute coupled with a corresponding increase in respiration rate. Subsequent flights proved that all pilots experienced similar rises in pulse

Bendix SYNCHROS

TYPES 1, 3, 5 and 6



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1 HDG	2325-1-C	MIL-S-2335	TDX	90/90	60
1 HG	2324-1-C	MIL-S-2335	TX	115/90	60
1 HCT	2323-1-B	MIL-S-2335	CT	90/57.3	60
3 D	2345-1-A1	MIL-S-2335	TDR	90/90	60
3 F	2328-1-A	MIL-S-2335	TR	115/90	60
3 HG	2327-1-A	MIL-S-2335	TX	115/90	60
3 HDG	2337-1-A	MIL-S-2335	TDX	90/90	60
3 HCT	2326-1-A	MIL-S-2335	CT	90/57.3	60
3 HCTB	2356-1-A	MIL-S-2335	CTBM	90/57.3	60
5 D	2354-1-A	MIL-S-2335	TDR	90/90	60
5 F	2341-1-A	MIL-S-2335	TR	115/90	60
5 N	2368-1-A	MIL-S-2335	TR	115/90	60
5 SB	2357-1-A	MIL-S-2335	TRBM	115/90	60
5 HG	2340-1-A	MIL-S-2335	TX	115/90	60
5 HDG	2352-1-A	MIL-S-2335	TDX	90/90	60
5 SCT	2346-1-A1	MIL-S-2335	CT	90/22.5	60
5 HCT	2353-1-A1	MIL-S-2335	CT	90/57.3	60
6 HG	2344-1-A1	MIL-S-2335	TX	115/90	60
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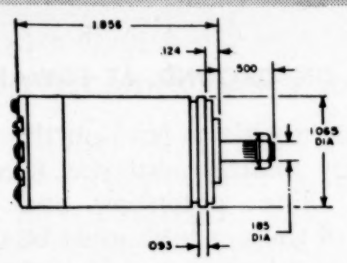

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11CX4c	AY1107-1-B2	MIL-S-20708/2A	CX	115/90	400
26V-11CX4b	AY1107-9-B2	MIL-S-20708/8A	CX	26/11.8	400
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26V-11TR4b	AY1104-13-B2	MIL-S-20708/5A	TR	26/11.8	400
11TX4b	AY1107-4-B2	MIL-S-20708/4A	TX	115/90	400
26V-11TX4b	AY1107-12-B2	MIL-S-20708/6A	TX	26/11.8	400
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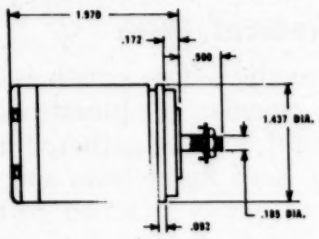

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15TR4c	AY1501A-5-B2	MIL-S-20708/19A	TR	115/90	400
15TR6a	AY1501A-12-B2	MIL-S-20708/23A	TR	115/90	60
15TX4b	use 15TR4c				
15CDX4b	AY1531A-3-B2	MIL-S-20708/16A	CDX	90/90	400
15CDX6b	AY1531B-9-B2	MIL-S-20708/22A	CDX	90/90	60
15TDX4b	AY1531A-7-B2	MIL-S-20708/17A	TDX	90/90	400

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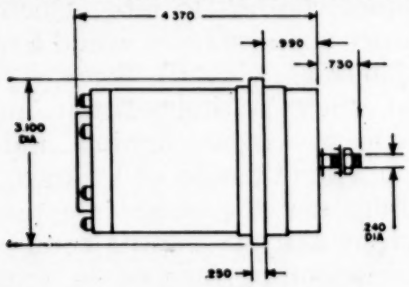

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31TR6b	AY3101B-13-E2	MIL-S-20708/66A	TR	115/90	60
31TX4d	AY3101B-4-E2	MIL-S-20708/61A	TX	115/90	400
31TX4a	AY3200-9-A1	MIL-S-16892	TX	115/90	400
31TX6b	AY3101B-12-E2	MIL-S-20708/65A	TX	115/90	60
31TX6	AY3201-4-A1	MIL-S-12472	TX	115/90	60
31TDR4b	AY3131B-8-E2	MIL-S-20708/63A	TDR	90/90	400
31TDR6b	AY3131B-16-E2	MIL-S-20708/67A	TDR	90/90	60
31TDX4b	AY3131B-7-E2	MIL-S-20708/64A	TDX	90/90	400
31TDX6b	AY3131B-15-E2	MIL-S-20708/68A	TDX	90/90	60

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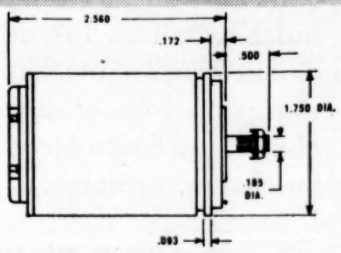
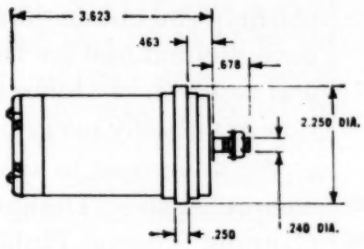
Bendix SYNCHROS

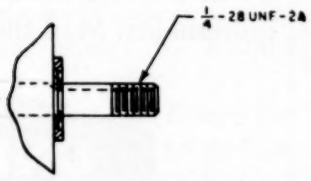
FRAME SIZE 18



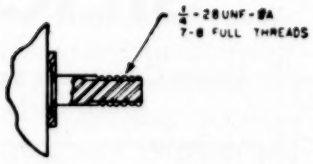
MILITARY TYPE NO.	BENDIX TYPE NO.	MILITARY SPECIFICATION	FUNCTION	VOLTAGE	FREQ.
18CT4b	AY1800A-2-D2	MIL-S-20708/29A	CT	90/57.3	400
18CT6b	AY1800A-11-C3	MIL-S-20708/34	CT	90/57.3	60
18CX4b	AY1800A-1-D2	MIL-S-20708/28A	CX	115/90	400
18CX6b	AY1800A-10-D2	MIL-S-20708/33A	CX	115/90	60
18TR4b	AY1800A-5-D2	MIL-S-20708/32A	TR	115/90	400
18TRX6	AY1800A-14-D3	MIL-S-20708/35A	TRX	115/90	60
18CDX4b	AY1830A-3-D2	MIL-S-20708/30A	CDX	90/90	400
18CDX6b	AY1830A-9-D2	MIL-S-20708/36A	CDX	90/90	60

FRAME SIZE 23





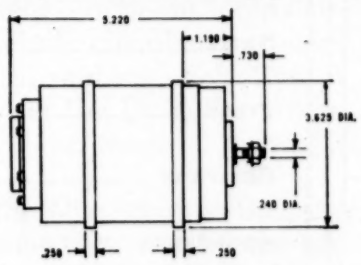
AY-2400 & AY-2430 SHAFT DETAIL



AY-2401 & AY-2431 SHAFT DETAIL

MILITARY TYPE NO.	BENDIX TYPE NO.	MILITARY SPECIFICATION	FUNCTION	VOLTAGE	FREQ.
23CT4	AY2400C-2-D2	MS-51082-4	CT	90/57.3	400
23CT4a	AY2401C-2-D2	MS-51082-4	CT	90/57.3	400
23CT4b	AY2401F-2-C2	MIL-S-20708/46A	CT	90/57.3	400
23CT6	AY2400C-10-D2	MS-51080-2	CT	90/57.3	60
23CT6a	AY2401C-10-D2	MS-51080-4	CT	90/57.3	60
23CT6c	AY2401F-10-C2	MIL-S-20708/53A	CT	90/57.3	60
23CX4	AY2400C-1-D2	MS-51082-2	CX	115/90	400
23CX4a	AY2401C-1-D2	MS-51082-2	CX	115/90	400
23CX4b	AY2401F-1-C2	MIL-S-20708/45A	CX	115/90	400
23CX6	AY2400C-9-D2	MS-51080-2	CX	115/90	60
23CX6a	AY2401C-9-D2	MS-51080-2	CX	115/90	60
23CX6c	AY2401F-9-C2	MIL-S-20708/52A	CX	115/90	60
23TR4	AY2400C-5-D2	MS-51082-3	TR	115/90	400
23TR4a	AY2401C-5-D2	MS-51082-3	TR	115/90	400
23TR4b	AY2401F-5-C2	MIL-S-20708/50A	TR	115/90	400
23TR6	AY2400C-13-D2	MS-51080-2	TR	115/90	60
23TR6a	AY2401C-13-D2	MS-51080-3	TR	115/90	60
23TRX6a	AY2401F-19-C2	MIL-S-20708/56A	TRX	115/90	60
23TX4	AY2400C-4-D2	MS-51082-3	TX	115/90	400
23TX4a	AY2401C-4-D2	MS-51082-1	TX	115/90	400
23TX4b	AY2401F-4-C2	MIL-S-20708/44A	TX	115/90	400
23TX6	AY2400C-12-D2	MS-51080-2	TX	115/90	60
23TX6a	AY2401C-12-D2	MS-51080-1	TX	115/90	60
23TX6b	AY2401F-12-C2	MIL-S-20708/51A	TX	115/90	60
23CDX4	AY2430C-3-D2	MS-51083-1	CDX	90/90	400
23CDX4a	AY2431C-3-D2	MS-51083-1	CDX	90/90	400
23CDX4b	AY2431F-3-C2	MIL-S-20708/47A	CDX	90/90	400
23CDX6	AY2430C-11-D2	MS-51081-1	CDX	90/90	60
23CDX6a	AY2431C-11-D2	MS-51081-1	CDX	90/90	60
23CDX6b	AY2431F-11-C2	MIL-S-20708/54A	CDX	90/90	60
23TDR4	AY2430C-8-D2	MS-51083-3	TDR	90/90	400
23TDR4a	AY2431C-8-D2	MS-51083-3	TDR	90/90	400
23TDR4b	AY2431F-8-C2	MIL-S-20708/49A	TDR	90/90	400
23TDR6	AY2430C-16-D2	MIL-S-12472	TDR	90/90	60
23TDR6a	AY2431C-16-D2	MIL-S-12472	TDR	90/90	60
23TDX4	AY2430C-7-D2	MS-51083-2	TDX	90/90	400
23TDX4a	AY2431C-7-D2	MS-51083-2	TDX	90/90	400
23TDX4b	AY2431F-7-C2	MIL-S-20708/48A	TDX	90/90	400
23TDX6	AY2430C-15-D2	MS-51081-2	TDX	90/90	60
23TDX6a	AY2431C-15-D2	MS-51081-2	TDX	90/90	60
23TDX6b	AY2431F-15-C2	MIL-S-20708/55A	TDX	90/90	60

FRAME SIZE 37



MILITARY TYPE NO.	BENDIX TYPE NO.	MILITARY SPECIFICATION	FUNCTION	VOLTAGE	FREQ.
37TR6b	AY3701A-13-C2	MIL-S-20708/74A	TR	.115/90	60
37TX4b	AY3701A-4-D2	MIL-S-20708/69A	TX	115/90	400
37TX6b	AY3701A-12-C2	MIL-S-20708/73A	TX	115/90	60
37TDX6a	AY3731A-15-D2	MIL-S-20708/76A	TDX	90/90	60

SYMBOL DEFINITIONS:

TX	Torque Transmitter	TDX	Torque Differential Transmitter
TXBM	Torque Transmitter Bearing Mounted	TDR	Torque Differential Receiver
TR	Torque Receiver	CX	Control Transmitter
TRBM	Torque Receiver Bearing Mounted	CT	Control Transformer
TRX	Torque Transmitter Receiver	CTBM	Control Transformer Bearing Mounted
		CDX	Control Differential Transmitter

SILICOLOGY

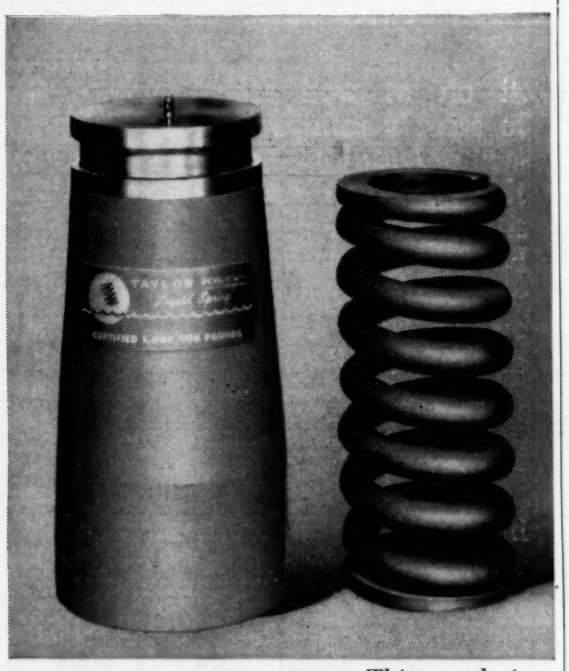
Studies in Silicones

HOW THESE TIME-TESTED MATERIALS CAN WORK FOR YOU

Do You Control Motion? Restrain, Release It? Silicone Fluids Are Helping Rewrite the Rules

Need a big-muscled spring to fit a pint-size space? You can now get a fluid spring 1/40 the size of an equivalent coil spring. Need a hydraulic shock absorber with a "flat-topped" energy absorption curve between minus 60 and plus 500 deg. F.? You can now get it. Want the two in one unit? You can get that, too.

The common denominator of such high-performance devices is a series of UNION CARBIDE Silicone Fluids. They range in viscosity from 10 centistokes to 100,000, with pour points as low as minus 85 and flash points above 600 deg. F.



MILLION POUND CAPACITY. This revolutionary, patented 1,000,000-pound Taylor liquid spring utilizing the precisely known compressibility of UNION CARBIDE Silicone Oil, is said to be the highest force spring ever produced in a single unit. Only a foot in diameter, it could support three of the largest locomotives. On top of it sits Taylor's smallest liquid spring. Beside it is a locomotive coil spring of almost the big spring's size, but providing only 10 tons of force.

COMPRESSIBILITY PLUS STABILITY

Two of silicone fluids' outstanding properties contribute greatly to their growing usefulness in a variety of hydraulic devices including springs, shock absorbers, torque convertors, dash pots, valve lifters, many more. These are compressibility—the highest known for polymeric fluids—combined with stability at temperature extremes.

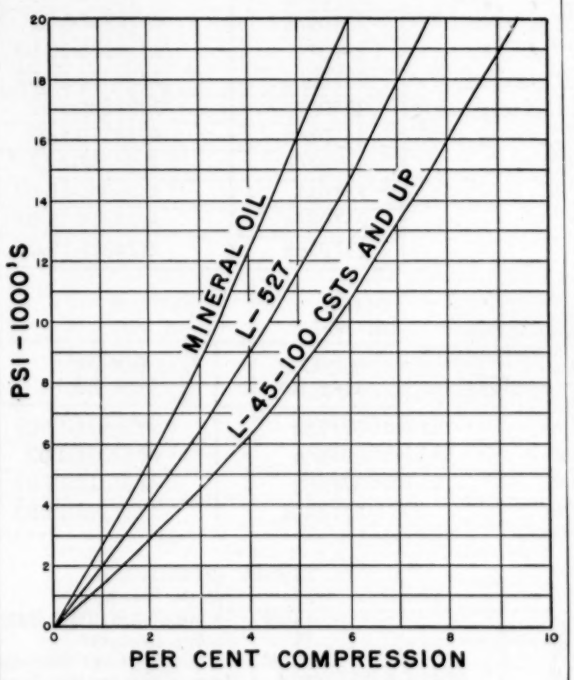
The per cent compressibility of UNION CARBIDE L-45 and L-527 Silicone Fluids, compared to conventional mineral oil, is shown in the accompanying chart. The viscosity temperature coefficient $\left(1-\frac{V210°F.}{V100°F.}\right)$ for L-45 with nominal viscosity of 100 ctsk. is 0.63.

NAME YOUR OWN SPRING RATE

Taylor Devices, Inc., of North Tonawanda, N. Y., is one of the companies adapting these highly useful qualities to hydraulic equipment. In tension and compression devices, for example, using a stepped tubular piston design and L-45 fluid, they achieve virtually any desired spring rate and force, within a compact, structurally stable mechanism.

Again, in spring-shock absorbers where high mechanical energy is converted to heat energy, Taylor Devices find UNION CARBIDE Silicone Fluids greatly extend the useful work range of the units.

Among the jobs such devices are performing are: Scram-rod cushions in nuclear reactors, taking impact loads on aircraft arresting hooks, cushioning aircraft radar antennas. In addition, they arrest circuit breaker mechanisms at interruption, stop rolls of paper on paper machines, and control feed rate of electrodes on electric furnaces.



Compressibility of UNION CARBIDE Silicone Fluids vs. Mineral Oil

R AND D TO HELP YOU

If you design hydraulic equipment for tough duty, your UNION CARBIDE Silicones Man has a wealth of technical know-how on the ways Silicone Fluids can help you obtain outstanding performance. Behind him are the vast experience and research of Union Carbide Corporation in virtually every field of industry.

We invite you to send at once for our comprehensive "Design File" on UNION CARBIDE Silicone Fluids for Mechanical Applications. It gives you in one handy package just about all you need to know about silicone fluids for your design requirements. Mail the coupon today.

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and respiration during the same portions of flight but it was noted that this did not measurably affect their performance.

Although this information may have been alarming to medical personnel when presented in quantitative form, its qualitative presence long has been known by pilots engaged in flying high performance aircraft. That the results were not unique to the pilots flying the X-15 has been proved by recent studies at the School of Aviation Medicine. Routine cross country missions have been conducted in F-100 aircraft by pilots carrying the instrumentation packs and data similar quantitatively to that gathered from the X-15 flights has been revealed. Most of the test pilots at Edwards agree that similar pulse and respiration rates have been experienced by pilots ever since man began to fly. This, however, is a rarely discussed point and has come to light only with the acquisition of the X-15 data.

Dyna-Soar Application

Data from each X-15 flight is carefully analyzed and then applied to the Dyna-Soar test program where applicable. AFFTC has been directed by ASD to be responsible for pilot selection and training, bioastronautics data and the conduct of the flight test program on Dyna-Soar.

Test pilots currently active at Edwards plus those pilots graduating each year from the test pilot school are being given extensive psycho-physical screening similar to that given to Project Mercury candidates.

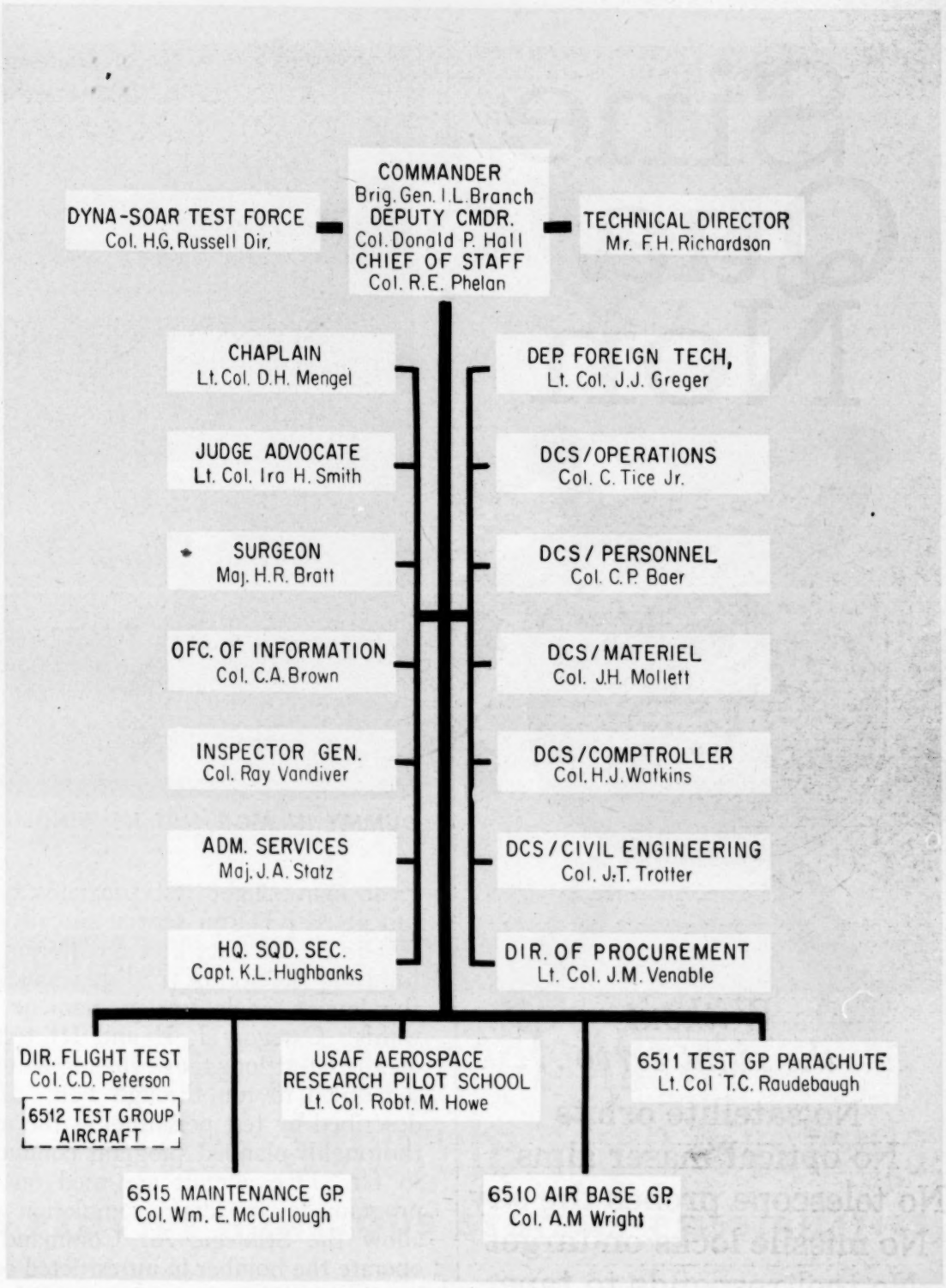
To date, none of the pilots tested has been rejected as a possible Dyna-Soar candidate nor has anyone been particularly recommended over another for selection. Criteria similar to those applied to the selection of the X-15 pilots and the rocket research craft of the past will be applied to the selection of Dyna-Soar pilots, namely, educational background, physical characteristics, flying experience and general performance of duty as observed by supervisory personnel. To the extent these criteria are applied to present flight test personnel at Edwards, Lt. Col. C. E. Anderson, chief of the Flight Test Operations Division, points out that nearly all of his working test pilots are potential Dyna-Soar candidates.

Each member has survived the psycho-physical testing processes, including centrifuge training, extreme heat environment, extreme cold environment, anechoic chamber tests and extensive physical probing. Selection of a pool of pilots for the Dyna-Soar training program will be made at Edwards within a year.

Mockup of the Dyna-Soar at Boeing/Seattle now is complete and for the last six to eight months, four fighter test pilots from Edwards have spent continuous rotational duty in an advisory capacity to Boeing on the Dyna-Soar cockpit and flight control system. These pilots are not necessarily Dyna-Soar selectees, but have been made available to Boeing to supply the answers to cockpit problems. In addition, AFFTC's two X-15 pilots, Maj. Robert M. White and Capt. Robert A. Rushworth have made repeated trips to Boeing to apply the experience they have gained in the X-15 to Dyna-Soar.

Col. Anderson points out that the Dyna-Soar project is directed by the System Program Office at ASD in Dayton and his pilots make no decisions regarding the program. They function as consultants to Boeing and do not represent the Systems Program Office.

A training program for Dyna-Soar also has been formulated at Edwards. Judging from the similarities of recovery and landing between Dyna-Soar and X-15 and the similarity of the launch of Dyna-Soar to that of Mercury, it is apparent that the training program will be a logical marriage of the two. Considerable centrifuge training to acquaint the pilot with the transverse accelerations of a rocket launch plus experience in Dyna-Soar simulators is expected.

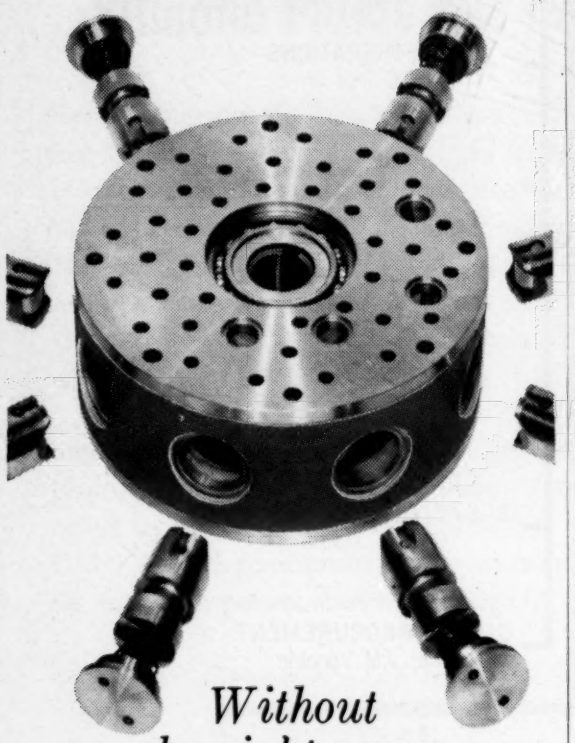


AFFTC ORGANIZATION

Recovery Techniques

Recovery and landing techniques can be sharpened through the use of drag-equipped F-104s and F-106s. Experience in the use of reaction controls can be gained in a specially equipped F-104 with such controls and special instrumentation added. It might even be desirable to obtain experience for the Dyna-Soar pilots by flying the X-15. Of particular value would be an unpowered X-15 flight preceding the initial drop tests of the Dyna-Soar glider from a mother ship, in a manner similar to early X-15 testing. It is anticipated that the X-15 program still will be active when Dyna-Soar first begins flight testing, just as there are still a

Sine Qua Non



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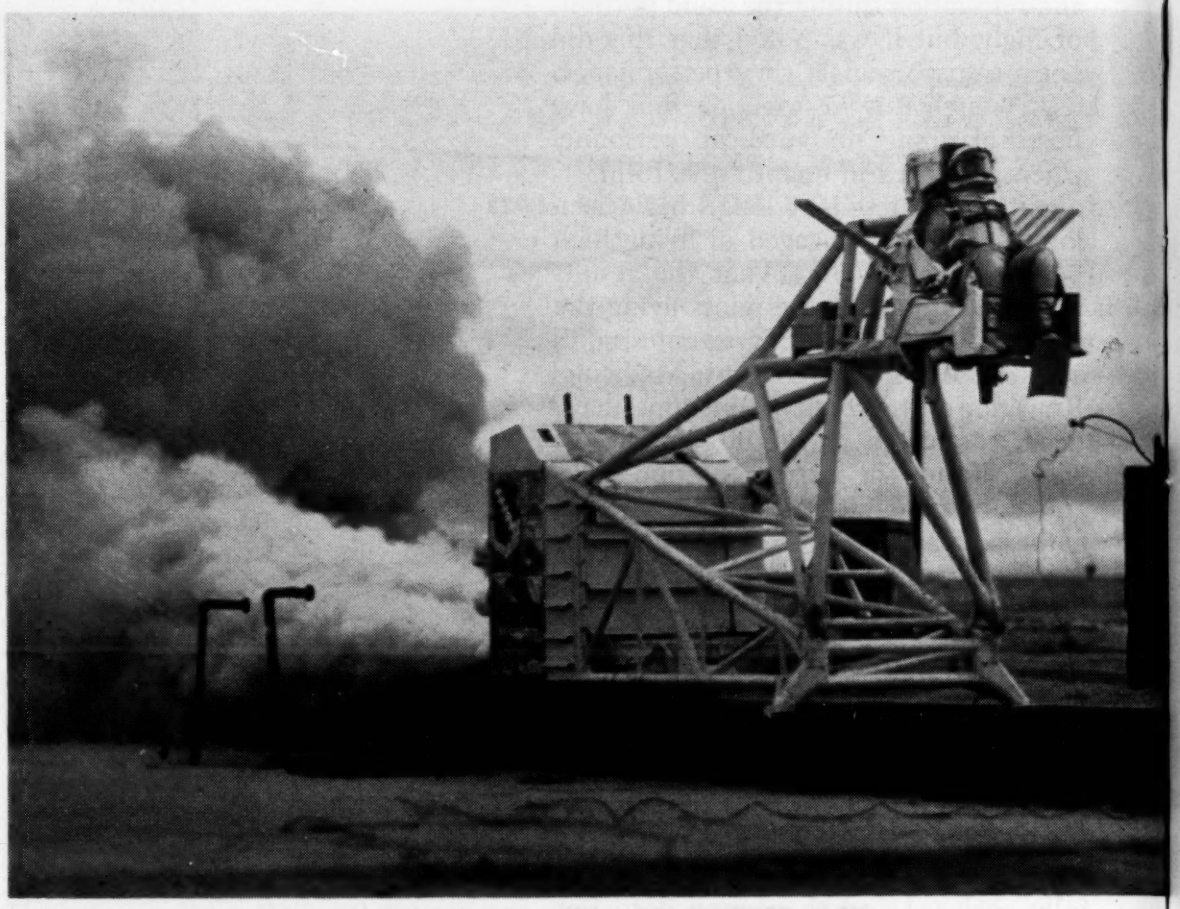


DUMMY IN MC-2 SUIT IN WINDBLAST TESTS ON ROCKET SLED.

great many flight test programs being run at AFFTC on service aircraft.

The B-52H Test Force, requiring the full-time service of 270 personnel, is the largest single test program at Edwards. Category I, II and III testing on the latest long-range Boeing bomber, scheduled to run through Feb. '62, is described by test personnel as the most thoroughly-planned program conducted so far. Five aircraft are used on the program to accelerate completion and allow the Strategic Air Command to operate the bomber in unrestricted combat maneuvers as soon as possible.

Testing Divided

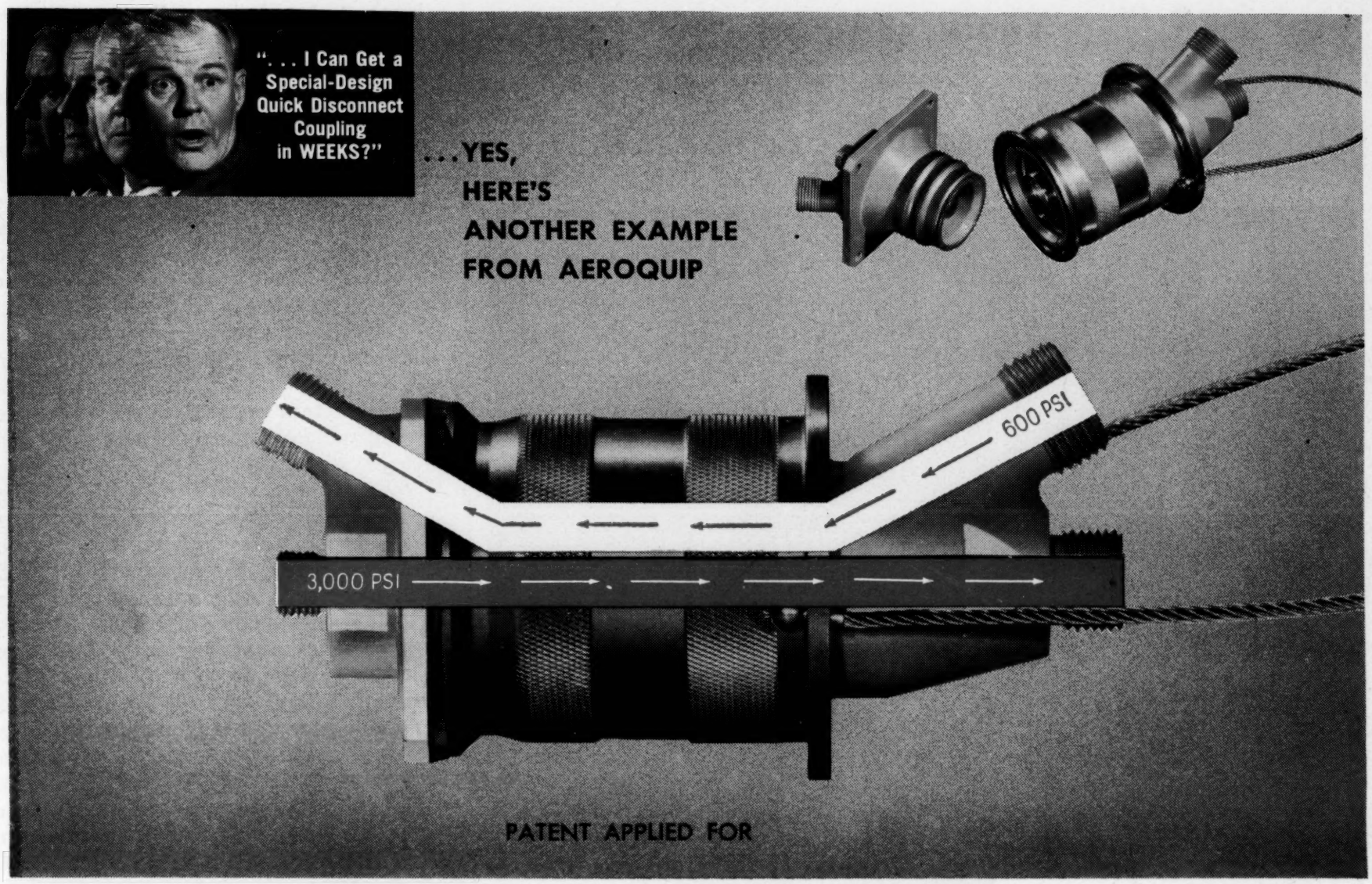
Under the category system, testing is divided into three parts rather than into seven phases as previous. During Category I, the contractor, in this case Boeing/Wichita, must demonstrate that the aircraft will fly as fast as the specification calls for. Category II comes under the responsibility of the Air Force Systems Command which conducts exhaustive tests to prove that all integral parts of the weapon system and its support equipment are compatible and function as designed. Category III testing is conducted by the major air command involved, in this case Strategic Air Command, with the purpose of orienting combat and support personnel and to develop any technique necessary to phase the weapon into the operational mission of the unit.

Under the Joint Test Force philosophy, personnel from the contractor, AFSC and the using command are welded together into a unit which sees the weapon through all three categories. Participation in each of the categories by personnel from the test force overlaps somewhat so that flight test crews start familiarization during Category I and using organization crews start checking-out early in Category II. As responsibility rotates from contractor to AFSC to using command, the number of personnel representing the responsible agency increases or decreases. This philosophy of concurrency and training during the testing has greatly reduced the drawing-board-to-operational status cycle, with resultant savings in money and manpower and the elimination of duplication of effort. The Joint Test Force represents an entity combining engineers and test pilots with skilled technicians from the contractor. These personnel are combined with crews from the using command where the system will be employed under operational conditions.

SAC Represented

SAC is well represented on the B-52H joint test force. Two cadres of 105 maintenance men are being used to keep the aircraft flying. The first group returns to its SAC units in October and will be replaced by a second cadre. These men will form the nucleus of maintenance crews at bases to receive the B-52H and provide SAC with a maintenance capability once the aircraft are received in number. Six SAC combat crews will fly missions from Edwards during the test program. These men will form StanBoard crews and return to SAC units to instruct other crews.

Two of the test force B52Hs are



New Dual Flow Quick Disconnect Allows Pressure and Return or Two Separate Fluid Systems

UNIQUE DESIGN OPTIONS PROVIDE NUMEROUS SYSTEMS POSSIBILITIES

An extraordinary quick disconnect utilizing two concentric fluid passages within a single coupling was developed by Aeroquip to help solve an umbilical connection problem on a second generation missile. This advanced design assures simultaneous connection or disconnection of both hydraulic pressure and return systems, required to protect system components on the missile.

Further research on the basic concept of concentric couplings by Aeroquip engineers led to a wide range of design possibilities now being employed on other systems. For example, two different fluids can be handled through one coupling. Or, addition of an integral by-pass valve port permits fluid circulation between passages in each coupling half upon disconnection—ideal for series circuits or for self-purging systems.

Aeroquip's superior coupling capability has been demonstrated many times by the development of special quick disconnects, such as this concentric coupling, to meet the requirements of a wide range of users. Your fluid line problems can be solved, too, by Aeroquip's unmatched engineering team. Mail the coupon below for details.

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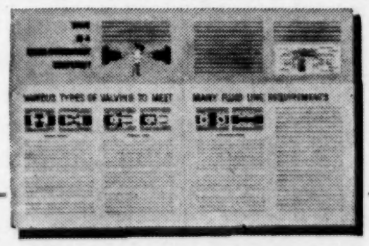
- . . . AND MANY OTHER TYPES



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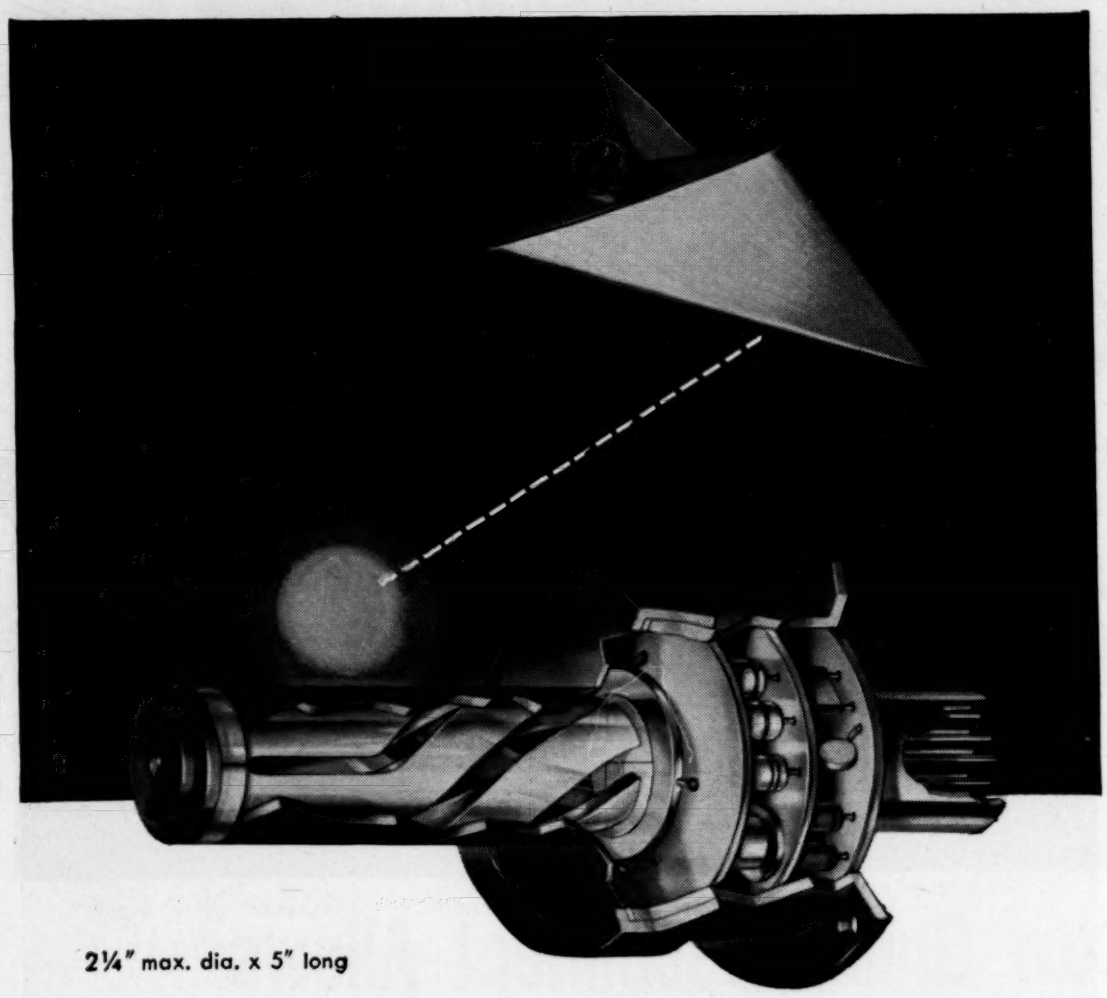
ENGINEERING
REPORT
ON BENDIX COMPONENTS



2¼" max. dia. x 5" long

BENDIX SUN SENSOR— RELIABLE REFERENCE FOR SPACE VEHICLE CONTROL

An important current E-P program is to develop components with high accuracy to meet spacecraft control system requirements.

The Bendix Sun Sensor combines a unique optical system with a simple four-section photo detector element. Result: a versatile instrument for many spacecraft control reference problems.

The sensor's signals are approximately proportional over a 2π steradian field of view to the sun's displacement angle with respect to the sensor boresight axis. The signals are also proportional, with a linearity of $\pm 1°$ over a field of view of 15° about the boresight axis. Resolution and tracking accuracy are $\pm 0.05°$, with a detector output signal gradient of 7.5 MV/0.1°.

Of significant advantage to null seeking control systems is the capability of deriving rate signals from the preamplifier output over the entire hemispherical field of view. Because of its highly linear, stable output gradient about null, the unit is also ideal for control systems requiring calibrated displacement signals.

Ask about the Sun Sensor's applications to specific control system functional, environmental and packaging requirements.

Eclipse-Pioneer Division
Teterboro, N. J.

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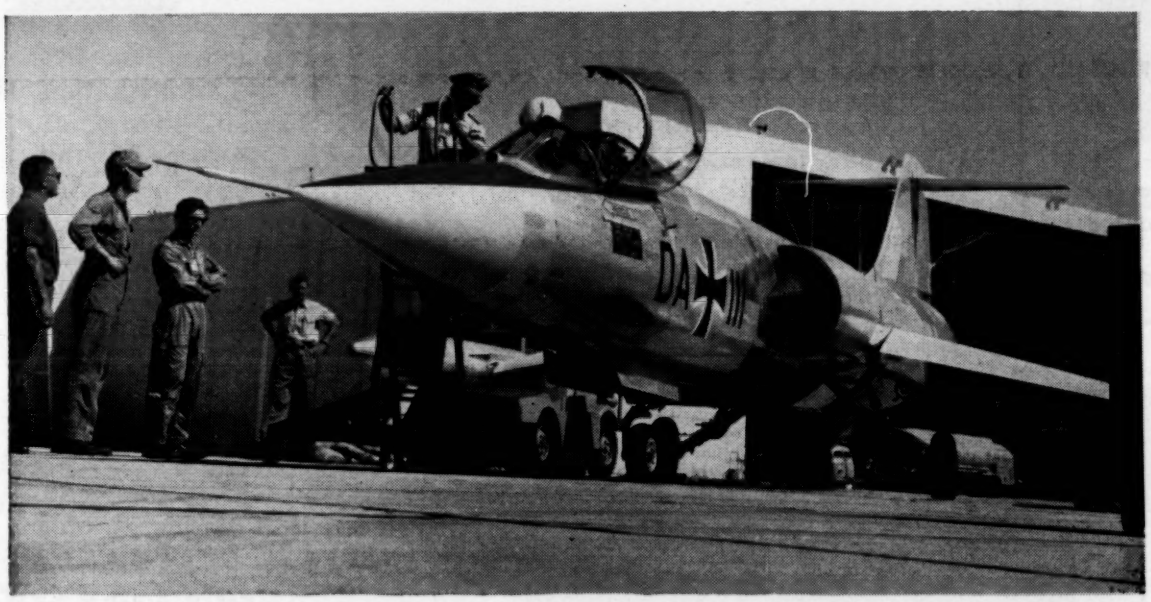
being operated out of Boeing/Wichita on Category I tests including flutter, performance, stability and control. Remaining aircraft are operated out of Edwards in Category II and III with participation by SAC and Air Training Command personnel. Approximately 1,200 hr. will be flown during the three categories with trips to the climatic hangar at Eglin AFB, Fla., and to Alaska for Arctic operation. The adverse weather aircraft is the most highly instrumented bomber ever flown, according to Test Force Director Maj. T. C. Kensler, with most of the instrumentation devoted to recording the operation and environment of the extensive avionic gear in the aircraft.

Of particular concern are the cooling requirements of the avionic gear during ground operation and in flight. The low-level penetrations planned by SAC will place severe demands on this gear which is equipped with automatic shutoff switches that are tripped if the various pieces of gear become overheated. Manual overrides can be used to force operation in emergencies. The severest conditions expected in service will be planned at Edwards to check the operation of all systems. One such test will allow the aircraft to soak in the desert sun with all hatches closed until past the hottest part of the day. The aircraft will be ground run for an appropriate period, then flown on a low level mission over the hottest part of the southwestern United States. The exact opposite type of mission will be conducted during the cold weather portion in Alaska this winter. Overnight cold soaking with hatches open will be followed by flights at maximum altitude.

The amount of coordination put into the test program is best illustrated by the flight profiles flown during the weapon system evaluation phase of the program:

- **Takeoff** from Edwards at 6 p.m. under hot weather conditions. Normal ground running of all equipment equivalent to pre-mission checkout will be made on all airborne equipment.
- **Dog-leg navigation flight** planned to bring the aircraft over Eglin AFB at midnight for work on the instrumented radar range. ECM equipment will be tested as well as measurements made of the electro-magnetic radiation properties of the aircraft and its systems. This will continue until about 6 a.m.
- **Defensive gun-laying radar** test against instrumented fighters sent up from Eglin.
- **Refueling operation** from KC-135 tankers off the coast of Texas and checkout of rendezvous equipment and techniques.
- **High-altitude bombing** runs conducted on the Radar Bomb Scoring



GERMAN F-104 AIRCRAFT AT EDWARDS AFB

sites in the Dakotas followed by a low level run to the Air Force Special Weapons Range near Albuquerque, N. M.

• **Return flight** to Edwards concluding a mission of 18 to 22 hr. duration.

Preplanning to such an extent allows the maximum use of the aircraft for testing all systems. Although it does not appear to be the case from observing the exterior of the craft, the H model differs so from the B-52s that the complete test program is required. Aside from the 40% increase in thrust provided by the turbofan engines, the additional avionic gear and other advanced systems make the gross weight much higher than earlier aircraft. In addition, low level missions in turbulent air requires a thorough demonstration of the structural integrity of the machine.

Performance, stability and control parameters will have to be investigated for various combinations of external stores for both high and low altitude operation. Extensive tests will be conducted with the GAM-77 Hound Dog missiles slung under the wings with the missiles' engines running and with engines off. Various combinations of GAM-87A Skybolt missiles also will be carried during the test program as well as the GAM-72 Quail decoy missile.

Program Highlights

Highlights of the test program include:

• **Radar bomb scoring runs** of seven different types totaling 81 high level and 84 low level missions.

• **Navigation legs** of 600 nautical mi. minimum, involving 50 hr. of high level and 50 hr. of low level navigation.

• **Fire control system tests** with the expenditure of 36,000 rounds of ammunition plus 400 to 480 fighter runs.

• **Electronic countermeasures tests** totaling 150 hr. against ground radars and a minimum of 30 hr. against aerial radars.

• **Chaff dispensers** of three different

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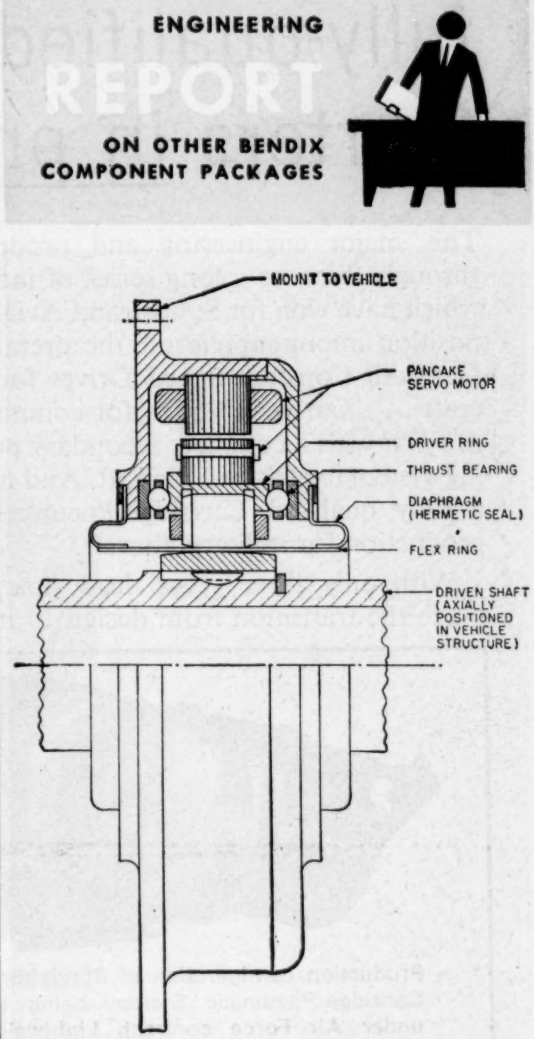

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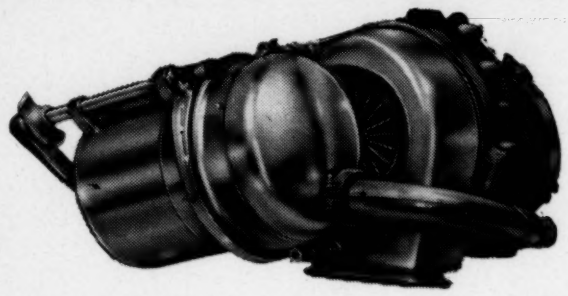
With only three years' lead time, Sundstrand made the transition from design to installation of this new pushbutton starting equipment, and on June 30, 1961, received acceptance and qualification from the Aeronautical Systems Division at Wright-Patterson Air Force Base.



Production configuration of Sundstrand B-52H Cartridge-Pneumatic Starter, being produced under Air Force contract. Lightweight self-contained unit for scramble or emergency starts.

The new Sundstrand dual-function starter is currently being produced for the B-52H and F-100, and installation studies are progressing for the KC-135, F-101, F-104, F-105, B-52A-G, plus various commercial aircraft. Custom installations can be designed for any type of military or commercial aircraft.

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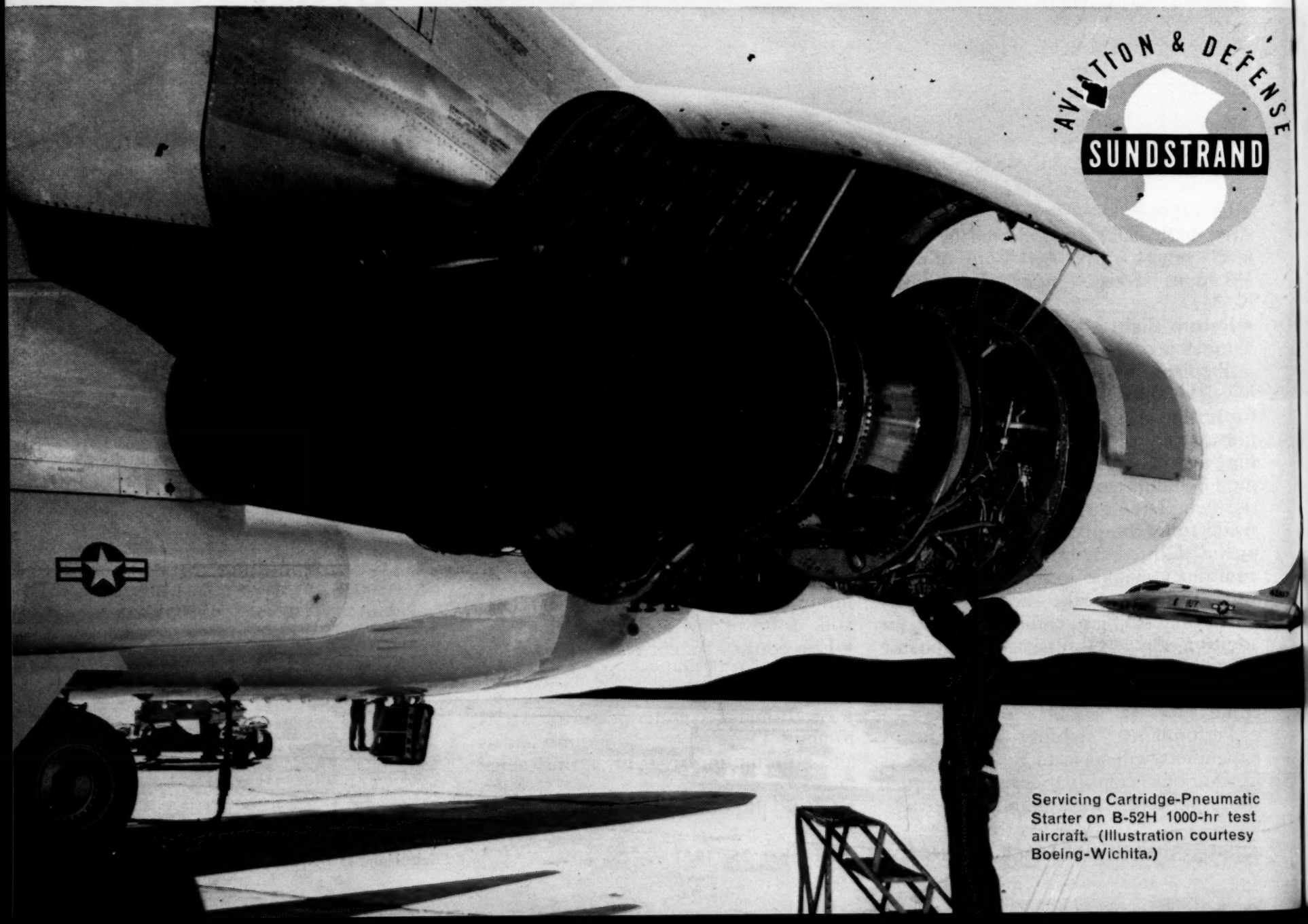


Servicing Cartridge-Pneumatic Starter on B-52H 1000-hr test aircraft. (Illustration courtesy Boeing-Wichita.)

types involving 8,000 units will be checked.

• **Low-level Advanced Capability Radar** (ACR) missions conducted in conjunction with the bomb-navigation system.

• **Air start** envelope of the North American GAM 77-A researched.

Many Air Force scientific agencies requested support utilizing the unique flying capabilities of the Lockheed U-2 for projects from the Special Projects Branch under the Flight Test Operations Div. Much of the U-2 development test flying had been done at Edwards and several of the machines were on hand. The Special Projects Branch, under Maj. Harry Andonion, was created to fulfill the requests by operating U-2s in support of as many requests as could physically be handled. The U-2's unique performance at extreme altitude over a long range generated requests, mostly of a study nature, amounting to three times the capability of the Special Projects Branch.

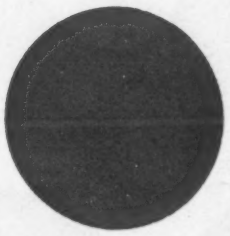
By careful study and combining, the maximum number of projects is supported, but still many requests are not fulfilled because of weight or space restrictions or because they are incompatible with other missions. Four U-2s are operated at Edwards. Two are single-place aircraft and two have navigator stations. The latter have been specially modified for research missions and have "picture windows" aft but are not equipped with dual controls or dual flight instrument panels. The navigators, in this case, are test equipment operators mainly concerned with infrared measuring equipment. Flying personnel in the branch include two navigators and six test pilot school graduates, of which branch chief Maj. Andonion is one.

Current programs in which the U-2s are involved are:

• **Infrared measurements.** Ballistic missile tracks are investigated for infrared propagation. A new type of airborne spectrometer is being evaluated. Solar radiation measurements are made with a John Strong spectrometer and other measurements of the IR background are taken for support of project Midas. U-2s operating out of Hawaii assist in the detection of re-entering Discoverer capsules.

• **Atmospheric variability studies.** High-altitude photos of cloud patterns have been made coinciding with the exact track and time period of the Tiros weather satellite to provide comparison between the Tiros pictures and actual high-resolution aerial photos. Cosmic radiation measurements are taken and water vapor content of the upper atmosphere is measured with the John Strong spectrometer.

Commencing in October, the Special Projects Branch will deploy to



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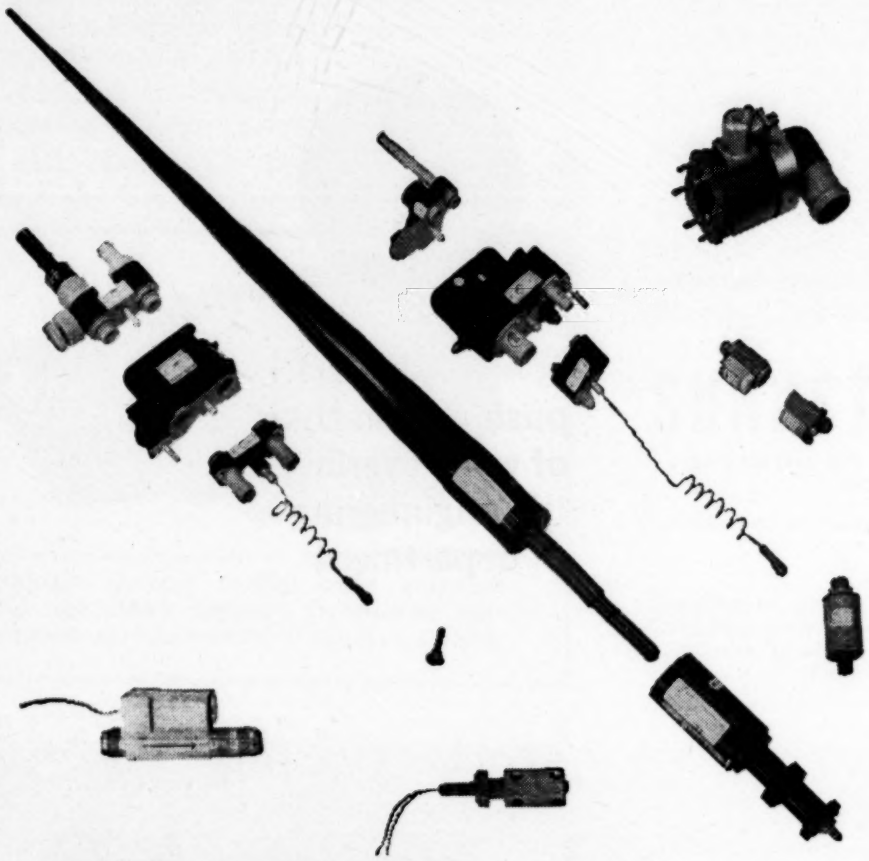

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south Australia for the first of a series of flights over the Antarctic ice cap for weather research. This will be followed by similar flights out of South America and possibly South Africa so that a complete picture of South Polar weather phenomena can be obtained.

Preplanning for these missions has been underway for some time because of the necessity of providing special fuel and crew oxygen for the U-2 as well as other support requirements. Although the craft does require special fuel which must be shipped abroad in advance, U-2 personnel report that the aircraft is virtually trouble free in day to day operation, requiring little more than refueling and routine inspection between flights.

Extra care is taken with personal equipment and with the various life support factors in the operation because of the high altitudes involved. U-2 pilots report that oxygen supply is plotted much more carefully on a long flight than is fuel. Edward's U-2s operate singly without special support on the long haul across the Pacific Ocean to Hawaii relying on ocean ship beacons and the Hawaiian Omni stations for navigational aids. Provisions for celestial navigation are included in the aircraft but are seldom used because the altitudes flown are above the level of strong winds and dead reckoning is sufficient to reach destination.

Discoverer Support

The aircraft's unique altitude capability also lends itself to supporting the Discoverer program and subsequent applications to Midas and Samos. Realistic simulation of re-entering Discoverer capsules is achieved by having the capsules ejected from high flying U-2s into a simulated recovery area. Crews in training with specially modified C-130 transports equipped to recover the capsules are not able to see the approaching U-2s adding to the difficulty of intercepting the capsules. The greater altitude capability, speed and range of the C-130s will allow considerably greater chances for success in aerial recovery attempts once they are put into operation replacing C-119s in Hawaii.

Characteristics of the capsule's aerodynamic behavior and parachute deployment also are studied by having another U-2 fly photo chase on the dropping aircraft.

Adding further to the weather research effort as it effects high-performance aircraft, U-2s of the Special Projects Branch provided photo coverage during thunderstorm penetrations for Project Rough Rider. The U-2 pilots were able to fly over the thunderstorms penetrated by the Rough Rider aircraft making both supersonic and subsonic

runs through the buildups. Photo coverage recorded the prevailing conditions and pilots were kept informed of the location of the buildups sought.

Another upcoming project will be the study of mountain waves in New Zealand and also the standing Sierra wave along the Rockies.

Support for the U-2s in their foreign operation is provided by a C-130 and a B-47 from Edwards although there is indication that a C-135 will be made available to support what looks to be a long continuing program.

Pilot Equipment

The U-2 aircraft are towed from within the hangar to a position near the end of the runway for reasons of pilot comfort and fuel conservation. Pilots, who have been pre-breathing oxygen for a minimum of two hours in their pressure suits while reclining in a special pre-breathing room, are whisked to the waiting aircraft in a "meat wagon." Little time is wasted in starting the aircraft and becoming airborne before the desert sun has had time enough to make the pressure suit-clad pilot in the cockpit unbearably hot.

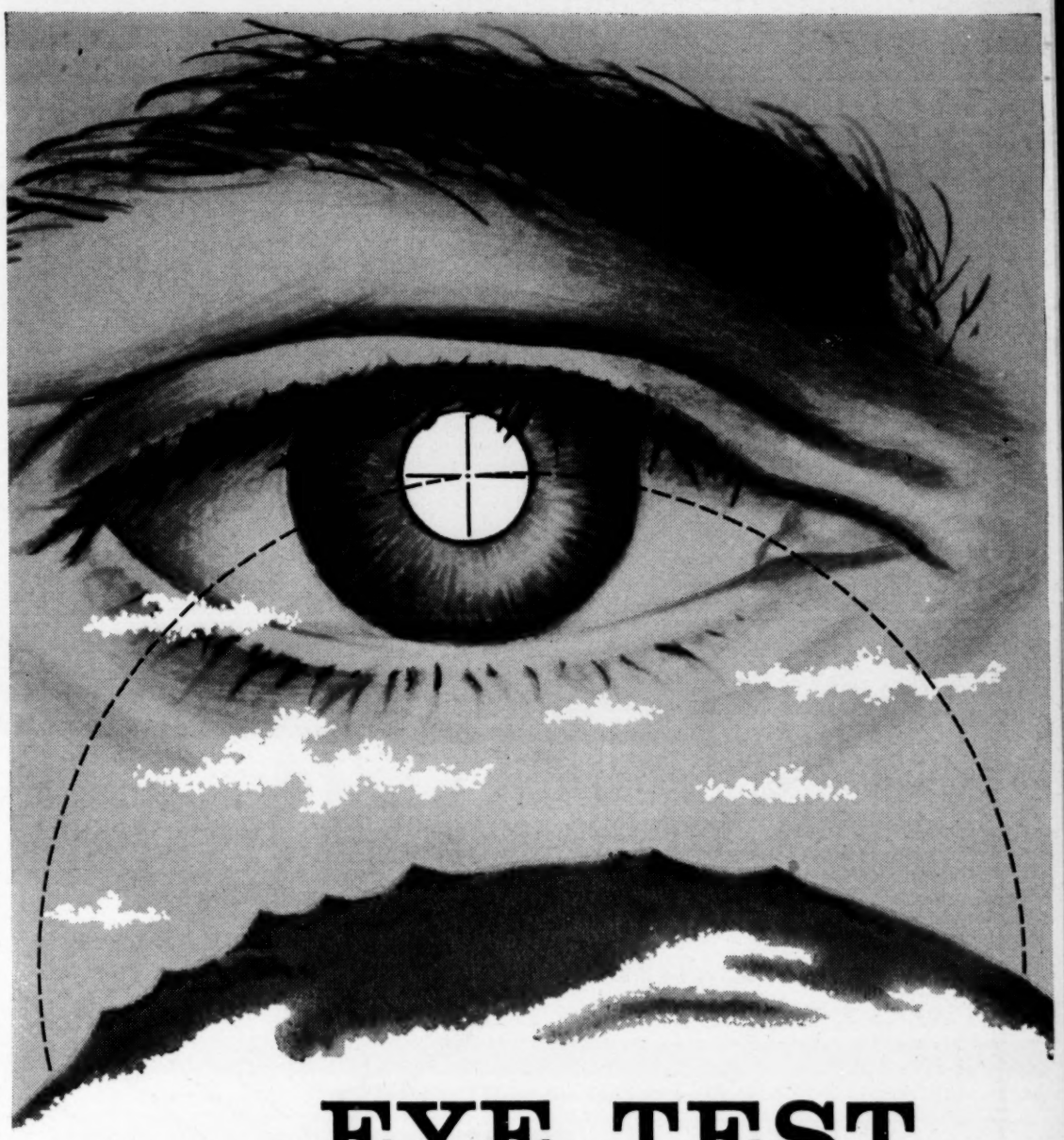
Each crewman has two specially-tailored pressure suits to which exacting attention is given. Care of and inspection of personal equipment is given a high priority in the U-2 operation.

Returning the U-2s to the hangar following landing has become somewhat of a game with pilots. It is possible by judicious use of the aileron and rudder controls to land the aircraft and bring it to a halt adjacent to the crewmen waiting with the droppable outrigger wheels. With the aid of a slight wind it is possible to keep either of the wingtips from touching the ground until the outrigger struts are installed. This is not a required part of the operation, but makes for good sport and competition amongst the pilots.

Fighter Test Force

The F-104G/J fighter test force is an international organization varying from 50 to 75 personnel composed of the top flying elements of seven nations. Under the direction of Col. William A. Kruge, the test force formerly reported to the AFFTC but as of Aug. 1 the international test force reports directly to the Systems Program Office in the Aeronautical Systems Division at Wright-Patterson AFB.

Joint testing of the F-104G/J is conducted along lines paralleling those spelling out category testing for Air Force aircraft under AFR 80-14. Test forces for both the German and Japanese versions of the Lockheed Starfighter are under Col. Kruge's direction but are physically separated. The F-



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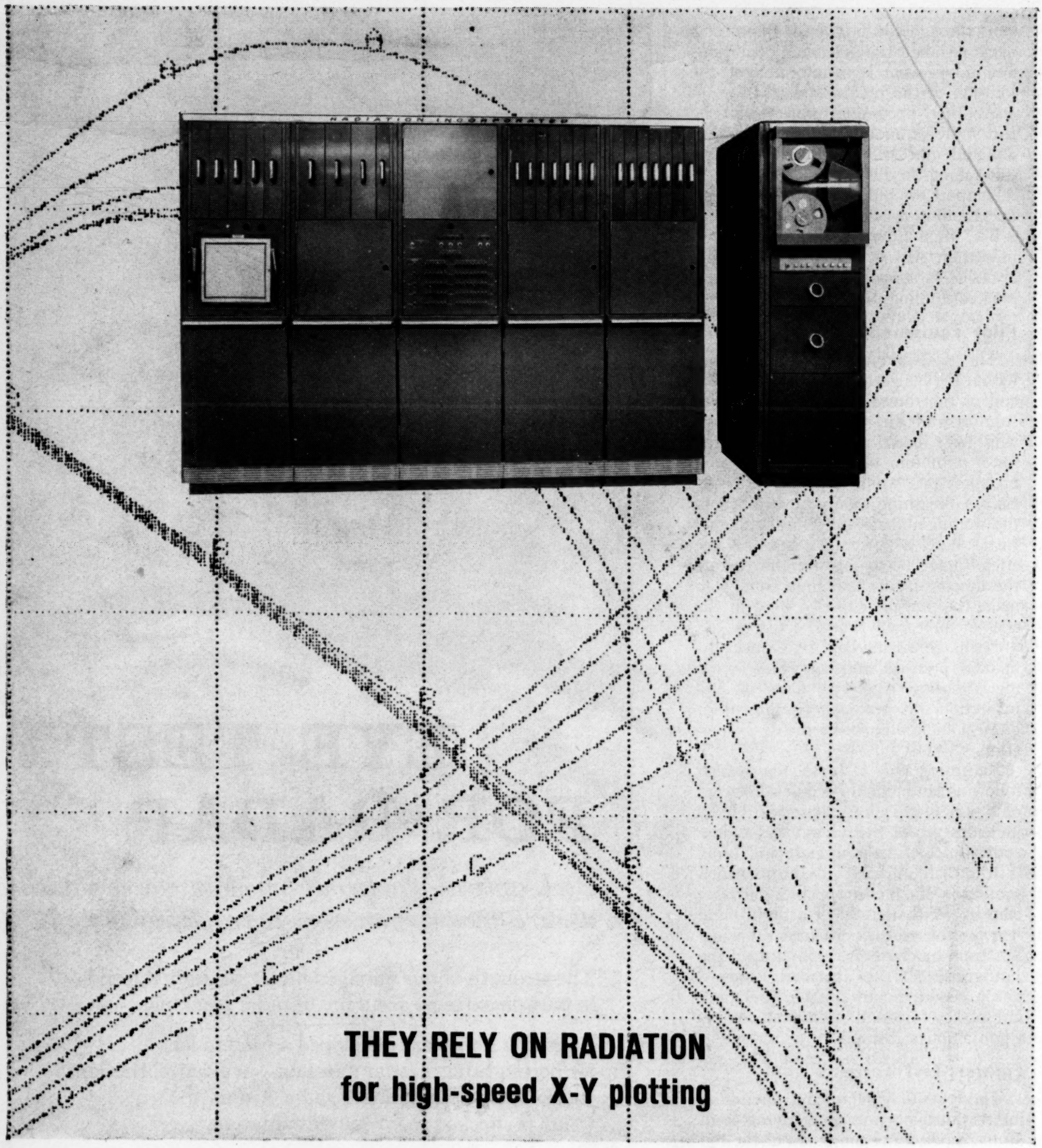

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104G test force operates from Edwards AFB in a hangar shared with USAF test aircraft. Testing of the Japanese version, which has only just begun, is conducted at Palmdale, Calif. operating out of the Lockheed facility there.

Category I testing, differing from USAF testing in that there is little participation by the contractor, is jointly funded by the USAF, the Royal Canadian Air Force, and the German air force. Complete category testing is essential because of the additional weight carried by the export version Starfighter. Extra structural strength also has been added to maintain structural integrity and support the added weight. Some of the features added to the foreign version of the Starfighter include an advanced version of the North American search and ranging radar (NASARR), automatic pilot, and more complex bombing, navigation and fire control systems.

Joint Test Missions

Four F-104Gs plus one supporting two-seat version are utilized in the program which involves 400 hr. flying time for Category I and II. Pilots of all the member nations—Germany, Canada, Holland, Belgium, and Italy—jointly fly the aircraft on test missions. Chase and support aircraft are provided by AFFTC as needed.

Category II testing will be a joint two-service effort with the USAF and the GAF participating. Pilots of each of the participating countries are well qualified and recent graduates of the USAF test pilot school. They are supplemented by flight test engineers from each country.

Although established along lines similar to Air Force regulations and operating from an Air Force installation, Col. Kruge points out that the joint test force is not USAF controlled. No decision relative to the conduct or direction of the test program is made solely by the USAF. Consultation with GAF members who are guided by a German Ministry of Defense liaison office in Burbank, Calif. always precedes any decision. USAF personnel in the program operate rather like a military assistance advisory group (MAAG) in reverse. Conduct of the program is on a co-equal basis.

Additional Category II testing is being conducted in the climatic hangar at Eglin AFB which is jointly manned under the direction of the fighter test force at Edwards.

Category III testing will be done in Germany commencing in February 1962. Again it will be a joint USAF/GAF program with some USAF personnel of the present test force moving to Germany for the program. It will be during Category III final suitability

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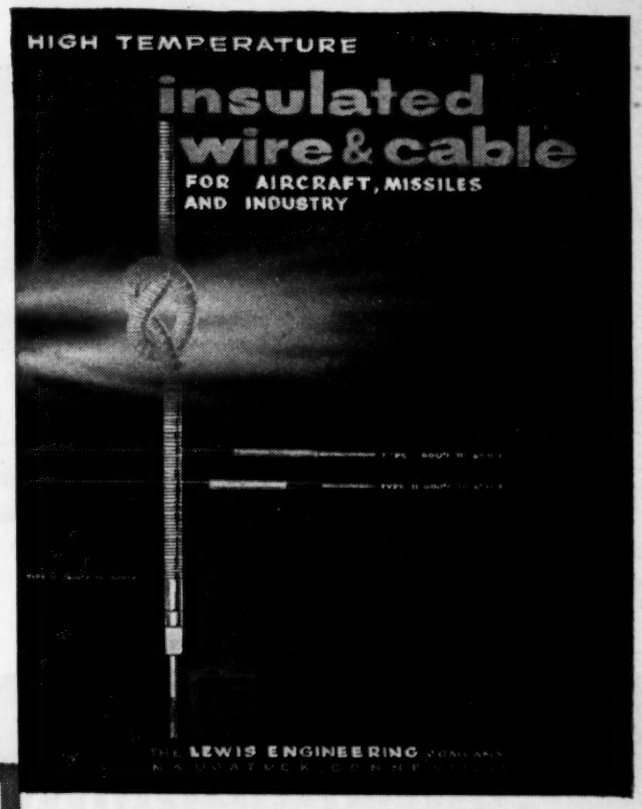

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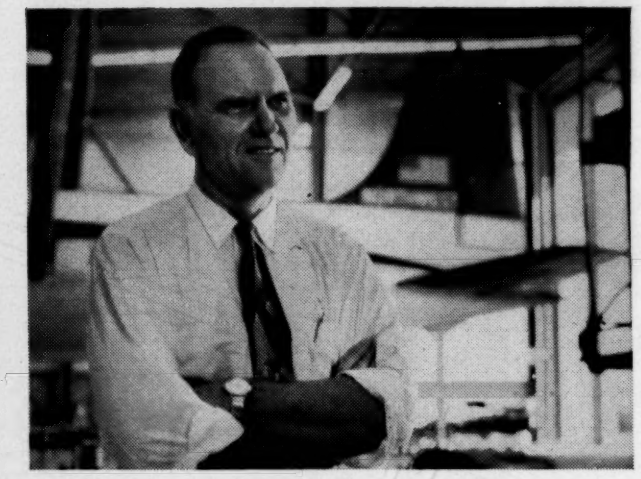

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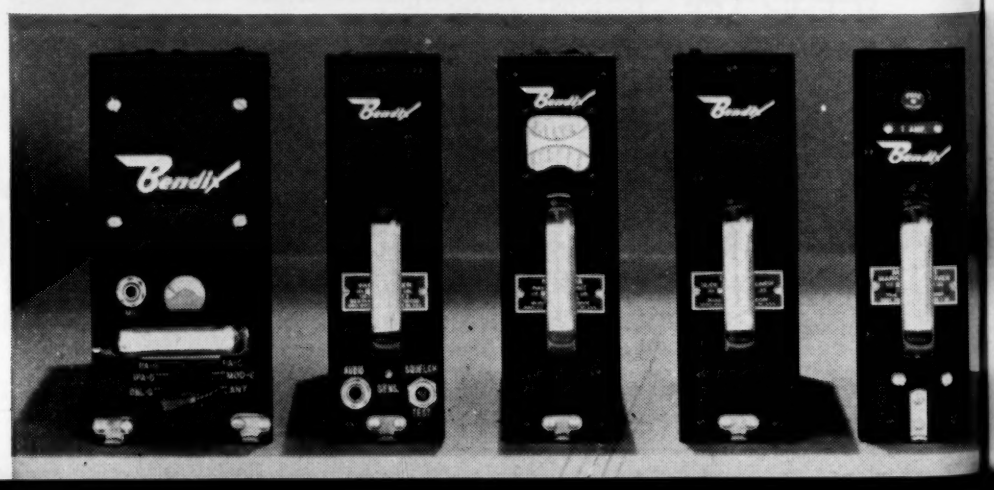

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tests conducted by using organizations that the remaining bugs in the aircraft systems will be uncovered and corrected. Many unforeseen problems might arise when the aircraft are operated in a relatively cold, damp German winter that were not realized throughout operation in the dry desert. Estimates are that Category II is approximately 35% complete at this time.

Category testing of the Japanese F-104J, while arriving ultimately at the same end product, will functionally differ slightly from the program on the F-104G. Category I and II testing will be a combined effort on the Japanese version conducted with equal inputs from Lockheed Aircraft Corp., USAF, and the Japanese Air Self-Defense Force. Structurally, the F-104G and F-104J aircraft are similar in nature, but differ slightly in the subsystems chosen by the customer country. Participation in the Japanese program by USAF personnel is limited to the same advisory extent as that in the F-104G program. Although the aircraft will continue to operate out of Palmdale, support will be provided by the AFFTC.

USAF Major R. L. Stephens is the international test force representative at the F-104J test site.

As in the case of the F-104J, Category III testing will be conducted in the customer country to permit participation of using organization pilots and evaluation of the complete weapon system in its operational environment. The F-104J program first flight was made June 30 at Lockheed Aircraft Corp.

Test Pilot School

Mission of the USAF Experimental Flight Test Pilot School under Lt. Col. R. M. Howe is to provide a continuing pool of experimental pilots to carry on with the development testing of current and future manned weapon systems.

Under a recent USAF directive, the school began to develop an Aerospace Research Pilot Course to train selected experienced test pilots in the testing and the evaluation of manned space vehicles.

The first student body is composed of one student and four faculty members of the present test pilot school. The course of instruction includes basic and applied space theory plus instruction and demonstration of applicable space flight techniques. Although students in the test pilot school include, as well as USAF pilots, those of friendly air forces, contractor personnel, and members of the Federal Aviation Agency, students in the Aerospace Research Pilot Course will be USAF personnel. At the appropriate time, Air Force Regulation 53-19 will be revised and the USAF Experimental Flight Test Pilot School will be redesignated the USAF Aerospace Research Pilot School.

Seventeen aircraft are assigned to the test pilot school: (5) T-28As, (6) T-33As, (3) B-57Es, (1) TF-102A, (1) F-104A and (1) F-104B. During the second half of Fiscal 1962, the T-28As will be replaced by Northrop T-38As and the inventory will be increased by (3) F-104Cs and an F-104D.

Pilot Training

The Aerospace Research Pilot Course is designed to provide the USAF with a pool of research pilots uniquely trained for the development and testing of manned space vehicles. A special curriculum in the highest-performance aircraft available will train the students in advanced techniques such as energy management, reaction controls, zero g, space vehicle landing characteristics and techniques, flight corridors and aeromedical physiological data acquisition. Simulator training will be relied on to a great extent when flight phases cannot be duplicated with aircraft. The X-15 simulator will be used as well as others to provide Dyna-Soar flight profiles and the dynamic re-entry simulation.

Much emphasis will be placed on bioastronautics to educate students in coping with the alien environment of space and to equip them for the stresses which will be imposed in space flight. Considerable time will be spent on field study trips such as one scheduled to the University of Michigan for an intensive two-week course in orbital mechanics and re-entry vehicles.

The 20,000-ft. experimental rocket sled track at Edwards was completed in May, 1959, although the first half of it had been in use for about one year prior to final completion. Originally built for model and full-scale tail flutter testing at subsonic, transonic and supersonic speed at a cost of $3,745,000, the track has been used to test parachute recovery, crew escape, missile and rocket guidance systems and the effects of rain erosion on aircraft radomes. The Experimental Track Branch also conducts research, development, and evaluation tests of missile and aircraft systems, munitions, special weapons and related components.

Rocket sleds, weighing from 1,400 to 14,000 lb., travel over the steel rails on special-alloy slippers at speeds ranging up to Mach 3. The fastest run was made by a 1,400 lb. sled at 2,050 mph. A 14,000 lb. sled has been propelled to 760 mph. Propulsion is supplied by either liquid or solid fueled engines. Solids are favored because of simplicity and high, short-duration thrust but the liquid fueled engines can be re-used and are considered more economical.

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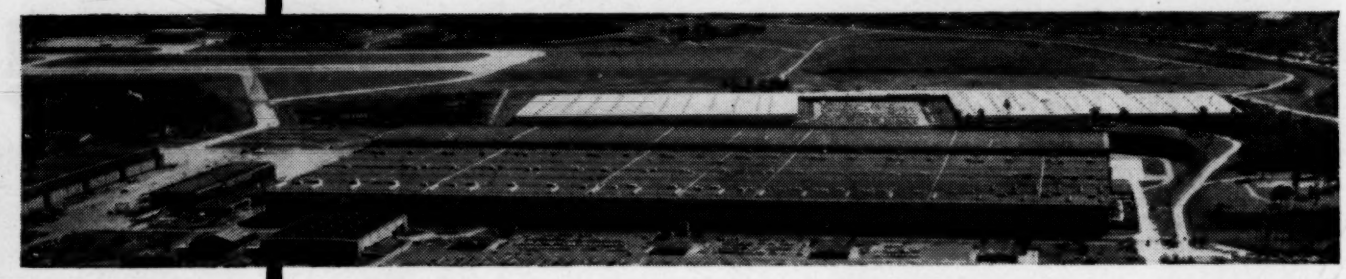

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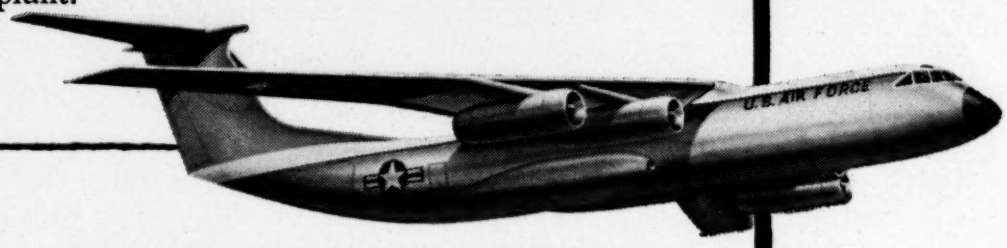

PROJECTS: Giant C-141 trans-world jet transports—Intercontinental C-130 turbo-prop transports—JetStar passenger craft—"Hummingbird" type VTOL aircraft—Missiles—Rockets—Nuclear Products—Nuclear Research—Avionics Research—Operations Research—Cryogenics Research—and scores more interesting long-range projects challenge you here.

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Write to: Hugh L. Gordon, Professional Employment Mgr., Lockheed-Georgia Co., 834 W. Peachtree St., Atlanta 8, Georgia. "Department Y-75."

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

THE ENGINEERING CENTER

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A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

Kirtland Guides Nuclear Weapon Effort

Air Force Special Weapons Center supplements AEC nuclear research, carries on AF-related programs

Albuquerque, N. M.—Although pressured by the constantly changing nature and scope of ballistic and space systems, as well as influenced by the moratorium on nuclear testing, the Air Force Special Weapons Center at Kirtland AFB has given USAF every nuclear capability in its inventory.

AFSWC does not of itself develop nuclear weapons or nuclear power systems. It does, however, guide the development of nuclear power and weapons by the Atomic Energy Commission to meet the needs of the Air Force. Supplementing the Atomic Energy Commission efforts in applied nuclear research, AFSWC also carries on a program in those areas that are best handled by Air Force personnel, aircraft and equipment. Closely monitoring the development of the nuclear state of the art, it is the responsibility of AFSWC to concurrently develop the hoists, trailers, suspension system, monitoring instruments, operational and safety procedures, etc. Thus when the nuclear systems become operational not only will the component parts mate, the necessary support equipment be on hand, but the necessary trained personnel will also be available.

According to Maj. Gen. Charles M. McCorkle, AFSWC commander, "AFSWC is an applied research organization rather than just a test organization. We are not a system manager for any particular project but we do work within many programs supporting foreign nations as well as the Army, Navy and civilian agencies."

In order to do the job required, Maj. Gen. McCorkle has divided the primary mission responsibility of his command among three directorates, namely the Research, Development and Test Directorates.

Col. D. L. Prickett's Research Directorate's efforts are focused on analyzing the basic phenomena associated with nuclear weapons and their effect on Air Force operations. While the moratorium on nuclear testing was imposed, a sizable laboratory program was undertaken to provide the simulation of the military effects and the phenomena associated with nuclear detonations in space. As a result of the reorientation necessitated by the moratorium, financing the nuclear weapons effect research has increased from approximately $1,900,000 in Fiscal Year 1958 to $7,900,000 in 1962. These funds will be expended in the three areas with which AFSWC has prime responsibility within AFSC: space nuclear effects, protective construction and radiation effects. Simulation facilities in each area of effects research already established or under construction are the following:

- **Air Force Shock Tube:** to obtain data on the dynamic effects of nuclear detonations.
- **Radiation Effects Laboratory:** to obtain fundamental data on nuclear radiation affects.
- **Pulse Power Laboratory:** to simulate certain portions of space nuclear d tonations.
- **Nuclear Warfare Laboratory:** (under construction) to conduct more extensive research in space nuclear weapons effects.

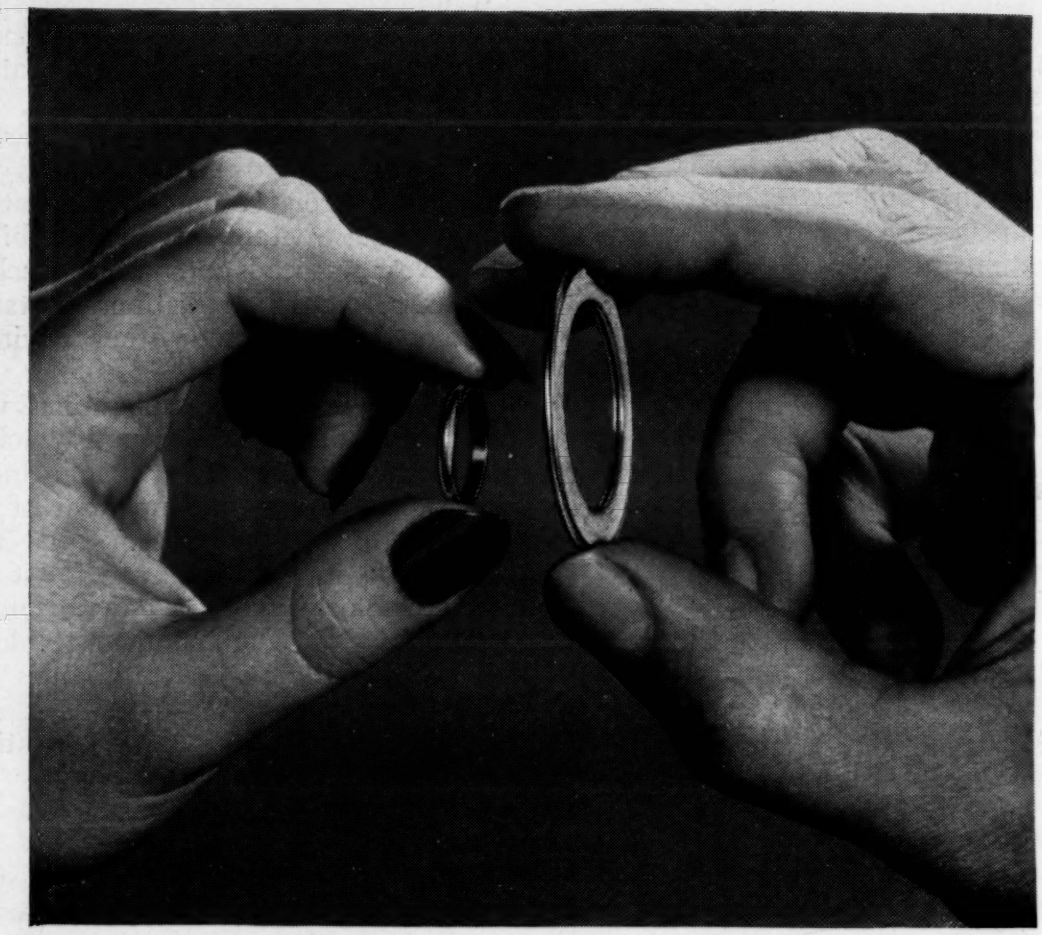
According to Gen. McCorkle, "The advances in nuclear weapons effects research, made to date in the era of "no testing" have been so substantial it is our opinion that full-scale tests will supplement rather than replace the simulation and theoretical research as a source of data."

The Research Directorate is in itself divided into the five following mission divisions.

- **Physics Division:** explores nuclear phenomena to determine areas requiring further research; defines importance of phenomena under special application or environments; probes for new, unknown effects phenomena and recommends action required; conducts research on theory of nuclear detonation phenomena; determines vulnerability of nuclear warheads in space to nuclear detonations, cosmic radiations, contaminations in space and other environments.
- **Biophysics Division:** determines vulnerability of man to natural, nuclear and man-made environments; includes determination and measurement of residual radiation and fall-out from nuclear operations of direct interest to USAF; monitors work of other agencies and conducts research into radio-biological instrumentation and procedures for decontamination of USAF vehicles and bases; conducts with USAF operating commands, liaison and technical instruction in personnel hazards due to nuclear operations.
- **Structures Division:** conducts, supports, guides, fosters and anticipates research in problems of effects of atomic blasts on structures and their contents; plans, conducts and supports the study of these problems by the most effective combination of major means of research. Studies will be mainly concerned with nuclear blast effects as they may influence the USAF retaliatory capability after a surprise enemy attack by means of passive defense measures. Provides consultants to military and civilian agencies.
- **Analysis Division:** conducts analyses of weapon systems and subsystems and makes recommendations to Hq. AFSC and Hq. USAF as to effectiveness of these systems; determines significance of special weapon phenomenology on USAF operations and important unknowns in weapon system analysis that need additional research or development; maintains liaison with Atomic Energy Commission on current state of the art and trend of future developments in nuclear weapons.
- **Special Projects Division:** manages technical aspect of AFSWC sounding rocket program, including technical co-

Maj. Gen. Charles M. McCorkle, Commander, Air Force Special Weapons Center, AFSC . . . born Newton, N. C., 1915 . . . graduate U. S. Military Academy, 1936 . . . graduated Kelly Field, 1937 . . . duties with 24th Pursuit Squadron, Panama Canal Zone . . . 31st Fighter Group at Salerno and Anzio, 1943 . . . returned to U. S. as Chief of Staff, First Fighter Command, Mitchel Field, N. Y. with 11 enemy aircraft to his credit . . . assigned to Flight Test Division, Wright Field, 1946 . . . Armed Forces Staff College, 1947 . . . chief of staff, Newfoundland Base Command, War College, 1950 . . . academic director, War College, 1953 . . . assistant chief of staff/Guided Missiles, 1956.

GASKETS
in Design Engineering



New, ultra-thin Garlock GUARDIAN* Gaskets solve the problem of high-temperature, limited-space sealing on missile and aircraft exhaust systems, turbines, other equipment.

At last—a spiral-wound gasket no thicker than a wedding ring! Ideal for limited space or light flange applications, this new Garlock GUARDIAN Spiral-Wound Gasket is available in thicknesses as thin as 1/16" in gaskets up to 6" I.D., maximum flange width 3/8".

Controlled density affords more positive seal. During manufacture of the new "wedding ring" GUARDIAN Gasket, the proper selected thickness of filler material and preformed metal, the number of laminations of filler and metal, and the correct tension of filler and metal while being formed into a gasket are the factors engineered to achieve proper gasket density. By controlling and varying these factors, Garlock is able to match the density to the pressure range. This built-in quality is constantly checked by a Baldwin-Lima-Hamilton compression-testing machine, thereby assuring perfect sealing regardless of different pressures and different bolt-load requirements.

High-temperature, high-strength construction. This new Garlock "wedding ring" GUARDIAN Gasket operates effectively at temperatures as high as +1900°F and pressures to 2500 p.s.i. or more. It is an excellent gasket where recycling temperatures are encountered. In the 700°F to 1200°F range, Garlock uses a compressed asbestos filler with stainless steel plies; in the 1200°F to 1900°F range, a ceramic filler is used with several different types of metal plies, depending on customer preference. The ceramic is non-flammable, completely inorganic, and an outstanding chemical insulator. It resists mold, mildew, and aging, thereby allowing indefinite shelf life.

Where service is severe and space at a premium, use new Garlock "wedding ring" GUARDIAN Gaskets. They may be the answer to your sealing problems. Find out more from your Garlock representative. Call him at the nearest of the 26 Garlock sales offices and warehouses throughout the U. S. and Canada. Or write Garlock Inc., Palmyra, N. Y.

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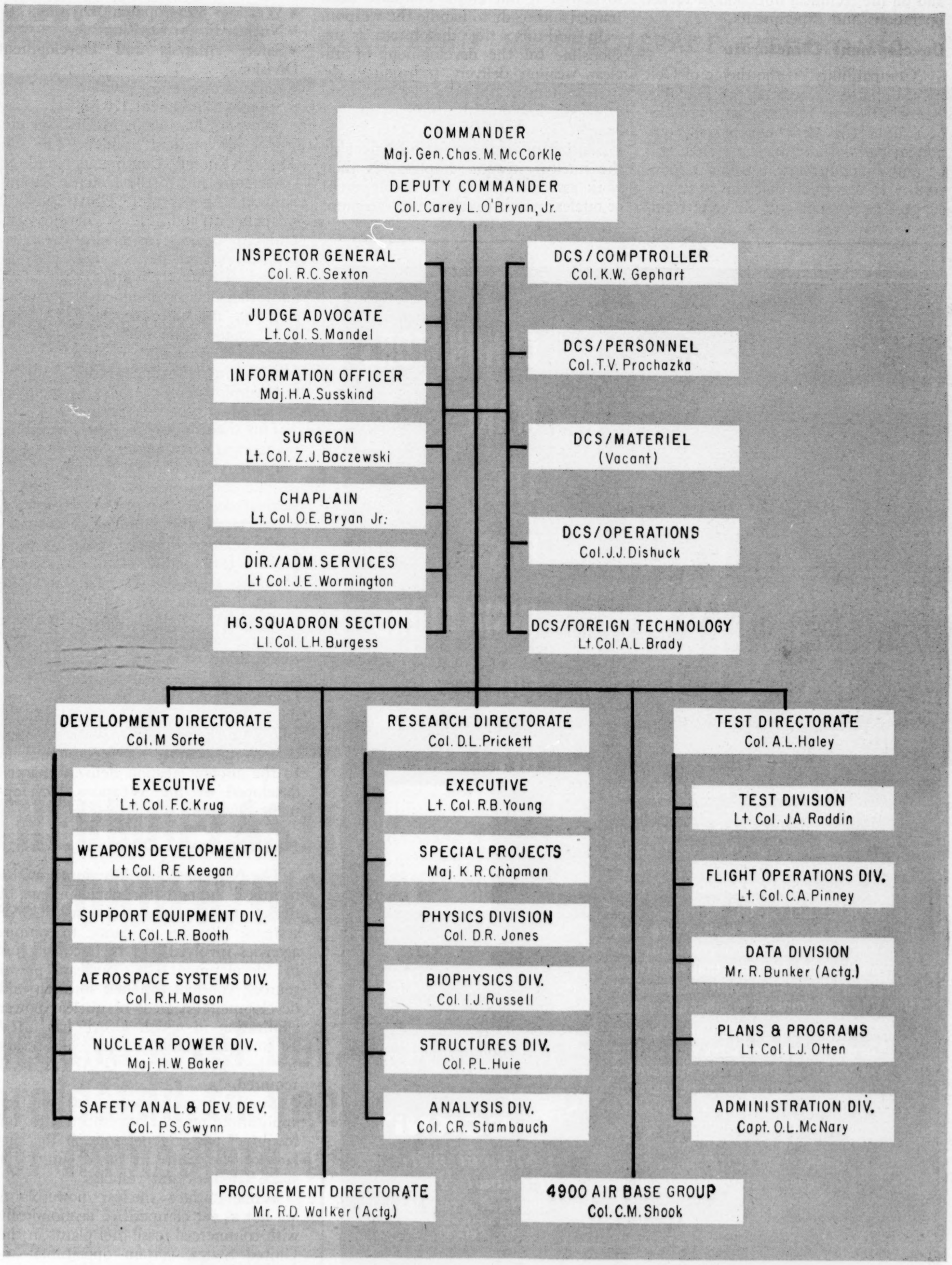
Organization of AFSWC



ordination with NASA on rockets, technical instruction of launch crews, technical aspects of procurement and modification of rockets and components and on-site technical direction of rocket operations and experiments.

Development Directorate

"Compatibility" is the theme of Col. M. M. Sorte's Development Directorate. His is not only the responsibility of assuring the Air Force that all component parts of any nuclear system will fit and function but it is his responsibility to see to it that the necessary support equipment and air crew training is developed concurrently with the nuclear technology. Therefore, when the weapon enters the stockpile, aircraft will not only have the capability to deliver it but crews will have been trained and ready to handle the weapon.

In addition, this directorate is responsible for the development of nuclear weapon delivery techniques, design criteria and safety analysis, and other Air Force applications of nuclear energy.

Sharing in importance and balancing the nuclear weapon emphasis is their work associated with the development of nuclear power sources as replacement for fossil-fuel electrical power sources and in advanced space systems.

Subdividing its mission into five areas of responsibility, Col. Sorte has delegated these responsibilities to:

- **Weapons Development Division.**
- **Nuclear Power Division.**
- **Safety Analysis and Development Division.**
- **Aerospace Systems Division.**
- **Support Equipment Division.**

Weapons Development Division provides development guidance to the Atomic Energy Commission and its contractors and to the Defense Atomic Support Agency for USAF nuclear weapons capabilities. It develops retardation devices for nuclear weapons, practice nuclear devices, new and improved delivery techniques, calculators, and other devices designed to augment, simplify, and improve the USAF nuclear weapon capability. It also conducts an associated applied research program in new concepts for weapons, and employment of these weapons in advanced aerospace systems.

This division works closely with the operational commands in the development of delivery techniques and in the organization of the aircrew weapon delivery manual. A typical example is the development of the low-angle drogued delivery (LADD) technique for fighter-bomber aircraft. Working with the Tactical Air Command the maneuvers for this delivery system were established from the safe escape studies and data as to the minimum time of fall for fuzing circuits provided by the Aeronautical Systems Division of AFSC. Continuous coordination with SAC, TAC, ADC, USAFE and PACAF also assure that the latest delivery procedures are incorporated in to the aircrew weapon delivery manual developed by the Weapons Development Division.

Nuclear Power Division

The Nuclear Power Division provides technical support for development of nuclear power systems for future USAF systems; provides guidance to various agencies involved and their contractors in development of nuclear power sources; conducts applied research and development in areas of nuclear power application in which USAF has interest and provides in-service engineering to the AEC and to USAF as it is required.

Nuclear power sources for military application range from substitutes for fossil-fuel power generators on the surface of the earth to power units for space satellites and vehicles.

While surface nuclear powerplants are not as yet competitive economically with commercial fossil-fuel plants in the United States, certain operational re-

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The paradox is: Radio Frequency Interference can only be contained with a conductor. Yet it is impractical to solder equipment closed to make a continuous shield. So, how to "insulate" with a re-closable RFI seal?

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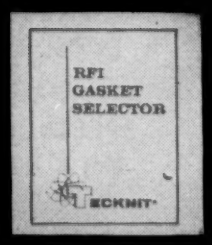
TECKNIT RFI Gaskets are available in many forms and sizes with varying mechanical properties and attachment methods. Selecting the right gasket is the basic factor in solving your RFI leakage problem and meeting MIL specs. A request for TECKNIT's RFI GASKET SELECTOR bulletin will receive return-mail attention.



Written with both mechanical and electrical engineers in mind, the RFI Gasket Selector shows how to pick the right type of gasket, sizes available, application and ordering information, limitations, and "ball park" prices.

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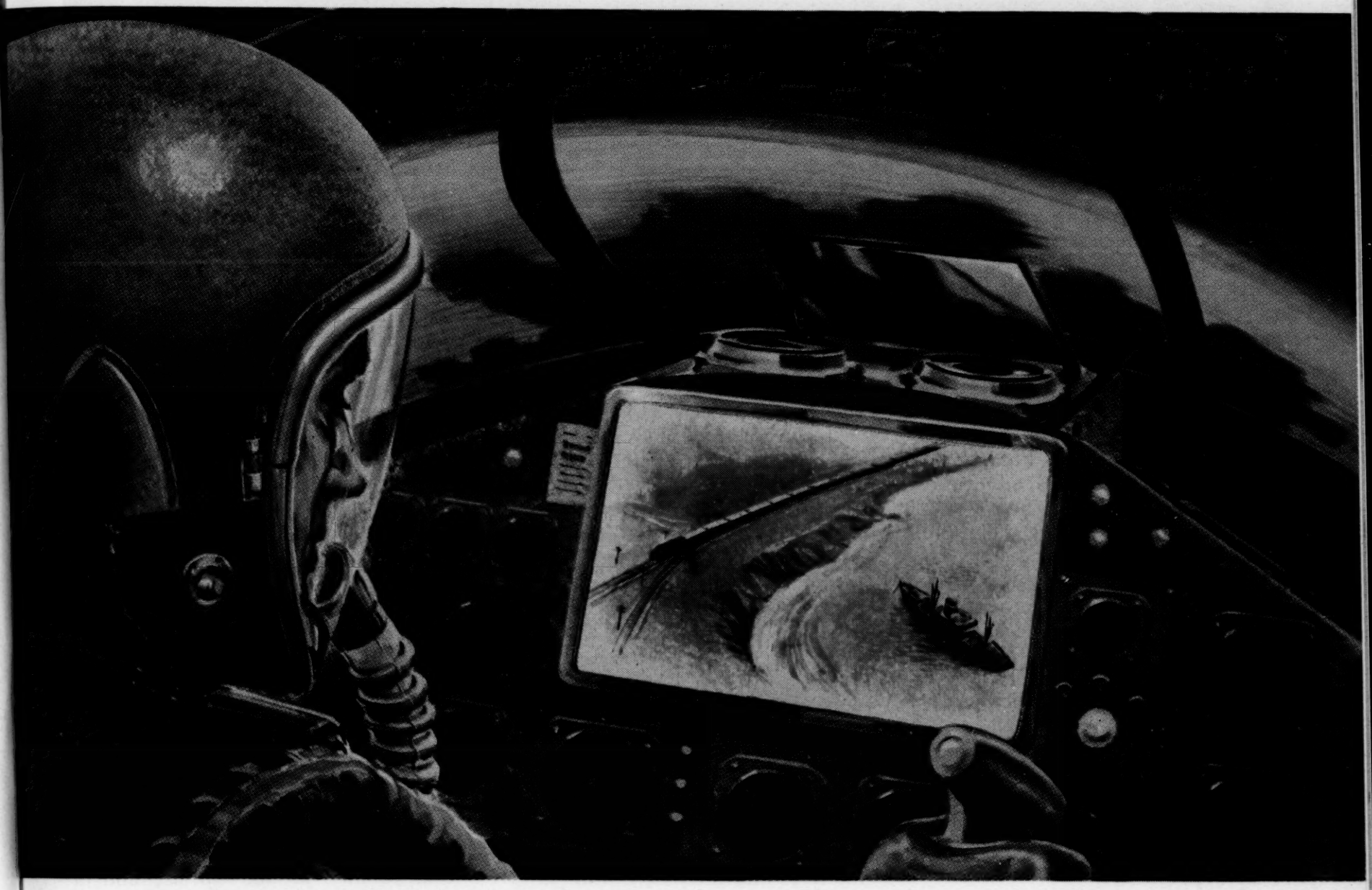

THERMOPLASTIC RECORDER/DISPLAY SYSTEM

Ground-level detail projected to vehicle for immediate use

At 40,000 feet and higher a pilot could spot ground-level targets no larger than a tank by using a new recorder/display system developed by General Electric's Light Military Electronics Department. A photographic view is obtained from side-looking radar, recorded on thermoplastic tape, and displayed instantly on a screen in the cockpit. Requiring no cathode ray tube, the screen has variable brightness that permits operation in ambient light, without the use of a hood.

At extreme heights—or in space—the system is capable of providing great detail and a permanent data record of TV, infrared, or any other "eyes" of the vehicle. Combined or composite displays are also possible for integrated display applications. The thermoplastic recorder/display system is a typical example of LMED contributions to progress in aero/space electronics. 150-07

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GENERAL ELECTRIC

Light Military Electronics Department
Utica, New York

USAF'S FIRST NUCLEAR powerplant is now under construction near Sundance, Wyo.

quirements override the cost factors. In remote areas of the globe where the high-cost of transporting the fossil fuel is prohibitive, nuclear power is economically feasible.

First operational USAF ground nuclear reactor will be installed at the Sundance, Wyoming, Radar Site sometime next year. The Nuclear Power Division of AFSWC is conducting the complete safety analysis of the proposed installation and will provide engineering services throughout its lifetime.

There are three types of nuclear power devices which are being developed for space applications. These include:

- **Space nuclear auxiliary power** (Snap) units to provide high power levels for long time periods in satellites and space vehicles.
- **Nuclear Rocket** (Rover) for use as an upper stage on advanced chemical boosters such as Saturn and Nova.
- **Project Orion,** the only proposed system which has the potential for lifting extremely large payloads into space.

Associated with the use of nuclear power systems in space is the question of what happens to the radioactive components of the nuclear power source when the space vehicle enters the atmosphere. A full applied research program presently under way in this division involves the ejection of simulated radioactive power sources from space missiles to determine the burn-up characteristics of the component parts during the reentry phase.

Safety Analysis

Safety Analysis and Development Division of AFSWC is the AFSC agency that collects and assimilates all the technical data, and performs technical nuclear safety analysis and evaluation studies on all USAF nuclear weapon systems. These studies analyze the system to identify possible deficiencies with respect to safety and/or to provide guidance for whatever further development is required to enable the system to meet the following standards established by the Department of Defense:

- **Positive measures** to prevent weapons involved in accidents or incidents or jettisoned weapons from producing a nuclear yield.
- **Deliberate arming,** launching, firing or releasing except upon execution of emergency war orders or when directed by competent authority will be prevented.
- **Inadvertent arming,** launching, firing, or releasing will be prevented.
- **Adequate security** will be assured.

The investigation of all accidents and incidents involving nuclear weapons, nuclear weapon systems and related equipment is also the responsibility of the Safety Analysis and Development Division. Each investigation is made with the intent of precluding similar incidents occurring again by recommending engineering or procedural changes.

To date, the division has been responsible for conducting reviews and safety analysis of many of the advanced aerospace systems, pointing out probable nuclear safety problem areas and weakness in contractor proposals. As technical advisers, project officers from the division guide the production of nuclear safety films used in the operational training of personnel who will man and maintain the new systems.

Aerospace Systems

Mating the weapon to the aircraft and the warhead to the missile are the two main functions of the Aerospace Systems Division, commanded by Col. R. H. Mason. The division ensures compatibility of the nuclear and/or conventional weapons with the designated aerospace weapon system by providing the technical assistance, guid-

PLASTIC HUMAN SIMULATOR (left), tissue-equivalent dose rate meter (center) and a combined X-ray and gamma ray detector will be, or have already, flown into space to measure radiation effects (right).

ance, requirements and handbook data to Air Force Logistics Command and to the Atomic Energy Commission.

Pylon design and development, fit tests, safe separation studies and aircraft modifications are all areas in which the Aerospace Systems Division provides technical guidance. The division's effort on each system must meet the production schedule established for each system. Prior to the operational capability date, all facets of the system development must be accomplished so that everything—including the handbooks—is available to the using organization.

The Support Equipment Division has been responsible for the development of suspension and release systems, ground handling, loading and electrical control, monitor and test equipment for all aircraft nuclear weapons systems through either independent developmental work or through detailed guidance to airframe contractors. It conducts applied research programs to meet equipment needs of new concepts in weapons, aerospace weapon systems and nuclear power systems.

Possibly the greatest contribution to the operational capability of the Air Force has been development by the Support Equipment Division of the techniques and hardware of the "clip-in" aircraft bomb loading system. This development is similar to the rifle clip wherein ammunition is pre-processed into a packet that is loaded as a unit with a minimum of time and final preparation. Rigging of the weapons into the suspension mechanism and subsequent testing can be accomplished in an assembly area away from the confines of the aircraft bomb bay and at a time not dependent on the presence of the airplane. The ultimate success of this system, however, depended upon development of a new bomb handling trailer, which has been accomplished and is now in operational use.

Similarly, the "Universal Rack" with corollary munitions loading and handling systems have been developed for fighter aircraft.

Fuzing Techniques

Some of the most important work being done in this division is the applied research in fuzing techniques leading to fuze system developments of the sort that will pick up a target approaching at a closure rate of more than 10 times the speed of the fastest rifle bullet; discriminate against unwanted "targets" and fire the warhead in time to catch the target on the lethal envelope.

The advent of nuclear powerplants within the military services has brought with it a need for equipment of undeveloped capabilities that in no manner could be classified as "standard." Re-

FLYING COVER

From a distant ASW destroyer flies DASH* —an unmanned helicopter, observed from the ship by radar. Its mission—to deliver its weapon against an enemy submarine. Drone master control from the destroyer controls 'copter direction, altitude and weapon release. The shipboard and airborne radio control link is a product from Babcock, the world's leading designer and manufacturer of remote control and guidance systems.

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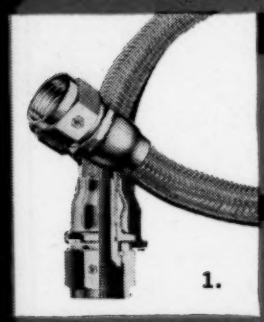
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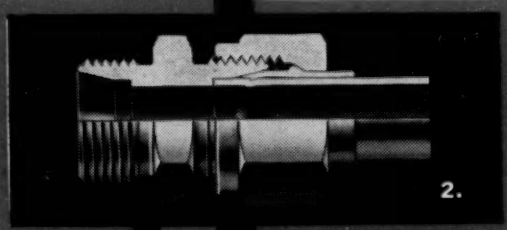
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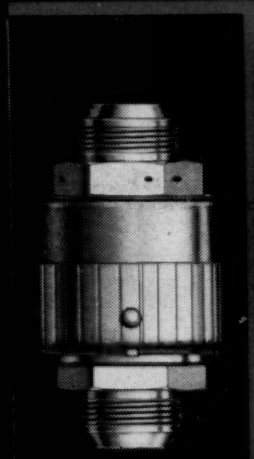
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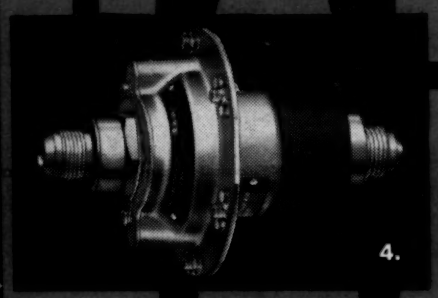
4.

It's the time when innumerable tests must pay off . . . a time when the word "reliability" has full meaning.

Meeting the critical needs of today's aircraft, missile and support equipment are Weatherhead precision fluid power components such as: (1) Teflon armor-plated hose assemblies combining the unique properties of Teflon with durable, leakproof Braid-Lok end fittings; (2) a complete range of MS (ER) flareless fittings designed to withstand the most severe applications; (3) quick disconnect, self-sealing couplings for straight-through flow with positive safety locking; and (4) breakaway couplings and regulators for missile guidance system power. These are only a few of the many Weatherhead standard and special precision aircraft products that give real meaning to "reliability".

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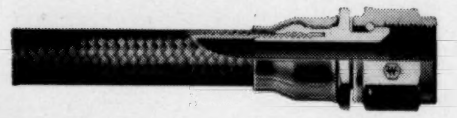

TEFLON* HOSE

Armor-plated hose assemblies, Braid-Lok permanent fittings and reusable fittings
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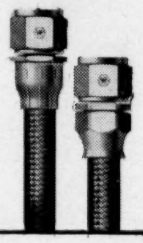
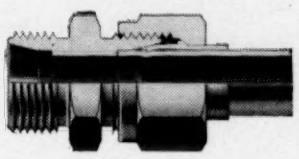


MS (ER) FLARELESS FITTINGS

Superior Seal, Extreme resistance to vibration fatigue, Reusable



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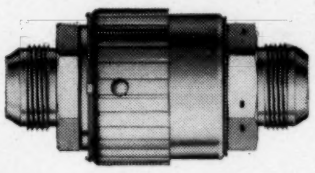
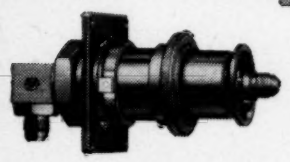
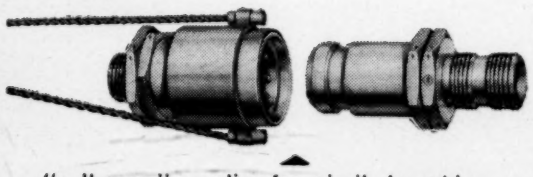
Self-sealing, Positive locking, Straight through unrestricted flow





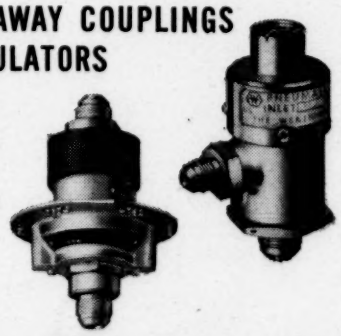
for liquid ammonia



"pull-away" coupling for missile launching

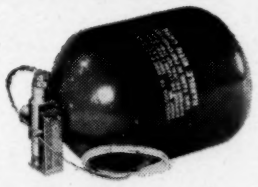
BREAKAWAY COUPLINGS & REGULATORS

For missile guidance system power and fuel system regulation



PNEUMATIC VALVE & BOTTLE

Explosive-actuated Provides power for missile guidance system



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mote manipulation equipment capable of moving about over unprepared terrain, handling relatively heavy loads or performing emergency recovery or rescue operations are just some of the areas to which this division has applied research studies to determine concepts and techniques required to achieve these capabilities.

Test Directorate

The Test Directorate headed by Col. A. L. Haley is not only the primary testing agency for the Special Weapons Center, supporting the Development Directorate in testing new weapon systems and the Research Directorate in the testing of nuclear effects in space, but it provides test support for other Department of Defense agencies in the development and improvement of both missile and nuclear systems and provides test support to the Sandia Corp. for the development of special weapons, as well.

Authorized a total of 341 personnel, consisting of 63 officers, 158 airmen and 120 civilians for the accomplishment of its mission, the Test Directorate is also assigned two B-52s, two B-47s, one F-100, six F-104s, two T-33s, two Fiat G.91s and one H-21.

Sharing the primary mission of the Test Directorate are three Divisions, namely the Test Division, Flight Operations Division and the Data Division.

The Test Division is the "proving ground" for engineering concepts and designs. From design sketches, Test Division draftsmen engineer working drawings from which materials and components are fabricated by the 4900th Air Base Group Experimental Fabrication Shops and then tested under the environment in which they would be utilized:

- **Spin tables** are used both to calibrate transducers under rotary acceleration and to determine their ability to function under predicted acceleration conditions.
- **Near-vacuum conditions** are simulated to determine the ability of components to function in this environment.
- **Accelerations** of 200 g's on objects up to 200 lbs. for periods of 10-15 milliseconds are imposed on subassemblies in a HYGE tester to test their susceptibility to shock.
- **Launch and boosted phases** of flight are simulated on a 10,000-lb.-capacity shaker to test and verify that instrumentation systems will function under anticipated operational conditions.
- **Temperature-altitude-humidity** conditions are also environments simulated to check out instrumentation systems. Thermal shock simulation is accomplished by transferring test articles from the 2,500F furnace to a −100F cold chamber. A controlled humidity chamber provides rain test environments up to four inches per hour.
- **Explosion chamber** tests the ability of electronic devices to operate safely in explosive atmospheres up to 80,000 ft.
- **Salt spray chamber** tests the corrosion resistance of components.
- **High- and low-velocity** sand and dust chambers determine the compliance of components with requirements of military specifications.
- **Electrodynamic vibration exciter** is capable of producing a sinusoidal force of 25,000 lb. and a random force of 52,000 lb. for systems testing operations.
- **Portable environmental chamber** is capable of being erected in any configuration to accommodate large or irregularly shaped articles. Temperatures from −80F to 160F are possible, together with up to 95% humidity. Combined environmental testing is achieved by erecting the chamber over shakers or static test frames. Another combined environments chamber provides a 32-cu.-ft. test cavity in which test items are subjected to altitudes of 270,000 ft. and temperatures ranging from −200F to 550F.
- **High-temperature furnace** tests components to 4,000F.
- **Static load test facility** includes a modular loading frame with a maximum length of 67 ft. and a cross section of 12 x 12 ft. in which loads of 250,000 lb. can be applied.
- **Bomb swing facility** provides precise determination of weight center of gravity and moment of inertia for calculation of safe separation and ballistic coefficients.

Flight Operations Division

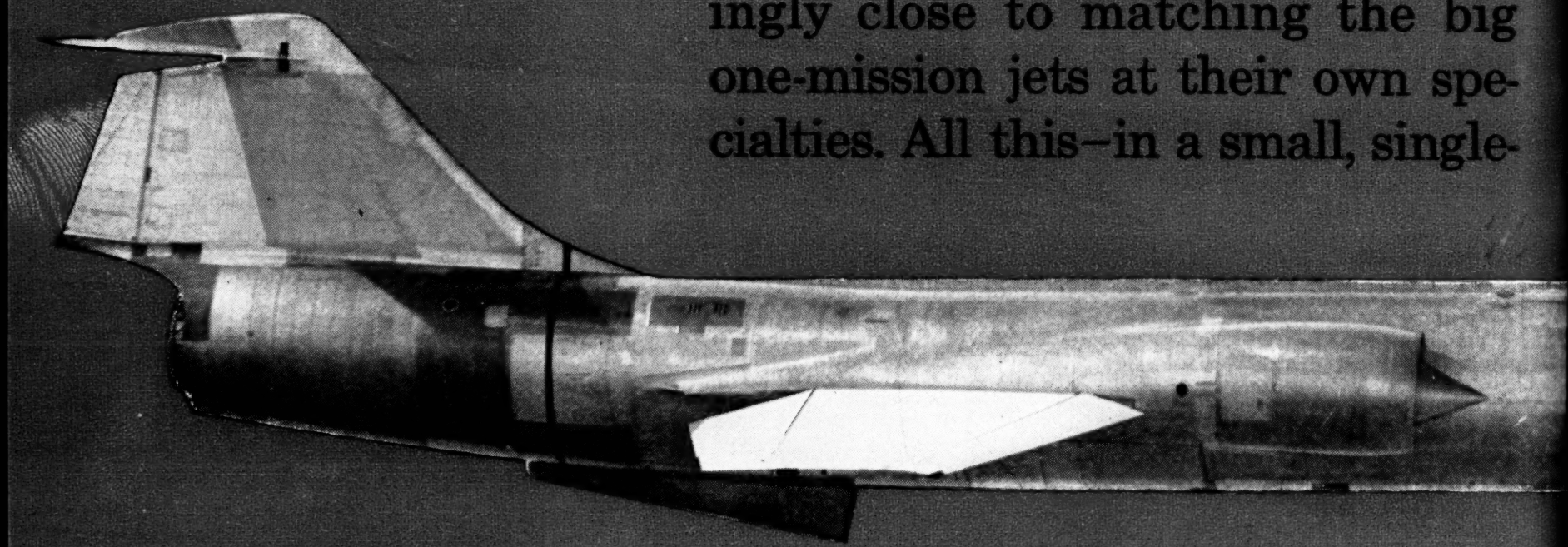
The Flight Operations Division supports the various Department of Defense Agencies as well as the Atomic Energy Commission in their space and missile and nuclear weapon programs.

Furnishing personnel, test aircraft and loading facilities, as required in their support of these agencies, the division utilizes the test ranges at Tonopah, Edwards AFB, White Sands Missile Range and the Pacific Missile Range primarily, although the Eglin AFB Range and the Atlantic Missile Range have been used on special projects.

As its name implies the Data Division processes the extremely large amount of information obtained at Kirtland. The division has an Analysis Section that performs analysis of mathematical and physical problems as well as conducting studies on projected scientific investigation and has a Computing Section which maintains and operates the IBM computers which handle this large mass of information.

A report on the Free World's F-104

The F-104 Super Starfighter is the best multi-mission * aircraft in the world today. No other aircraft can match it in time-to-climb, or in the variety of bombs, cannons, rockets, and missiles it can carry to Mach 2. And with the right combination of black boxes and weapons, the F-104 comes amazingly close to matching the big one-mission jets at their own specialties. All this–in a small, single-



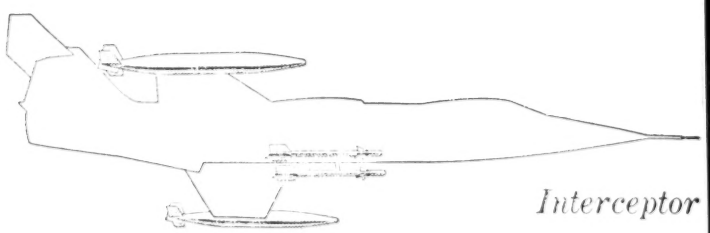
engine jet that's much cheaper to build, operate, and maintain... much cheaper to fly and service.

The F-104 is also the instrument that united seven Free World nations in a vast undertaking to forge one weapon for the common defense of all. F-104s are now being built by Belgium, Canada, West Germany, Italy, Japan, The Netherlands, and the U.S. Our allies

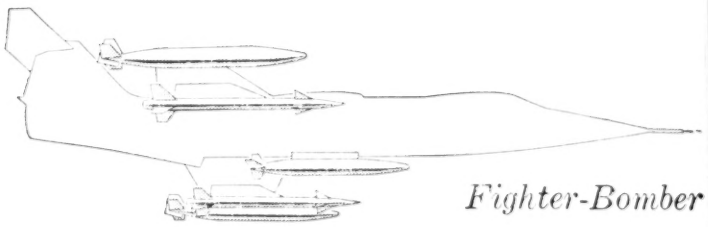
will build most of their F-104s in their own factories, with their own money. By the mid-Sixties, nearly 2,000 F-104s will be in service.

The F-104 makes sense for our allies. It gives them one plane that will meet any situation for the next 10 or 15 years; gives them interchangeable parts, planes—even pilots; gives them worldwide production that can be stepped up overnight in an emergency.

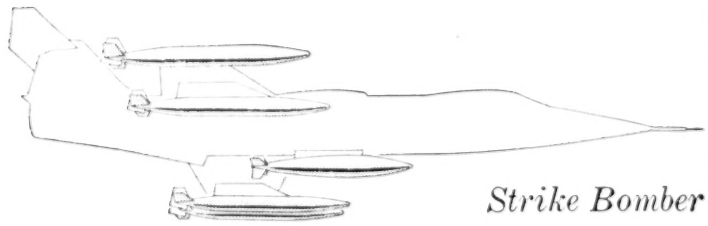
The F-104 makes sense for the U.S., too. Our allies are investing $58-million to develop this advanced version of the U.S. Air Force F-104. They have beefed up the structure and added a lot of new electronics to equip it for its many new missions. Thus, the Super Starfighter brings home the creative contributions of six other great air forces.



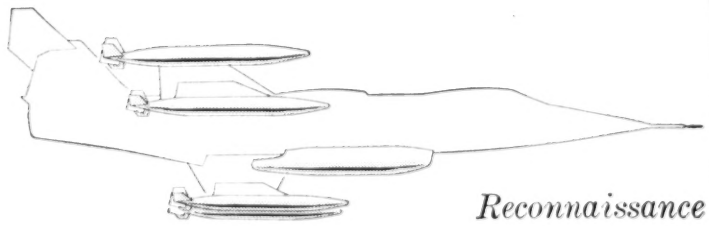
Interceptor



Fighter-Bomber



Strike Bomber



Reconnaissance

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Holloman Is Contributing Basic Research

Alamogordo, N. M.—The success of Holloman AFB as an Air Force Missile Development Center predestines its future as a significant basic research contributor to the Air Force Systems Command's role in interplanetary space.

Today, applying the studies that will make AFSC's lunar and other space plans feasible, Holloman AFB is actively engaged in three major Air Force requirements:

- **Aerodynamic systems testing**
- **Guidance system components testing**
- **Bioastronautic research.**

Its success in these three areas is identified with the unique facilities AFMDC possesses and which enable it to do the job.

Reactivated in 1947, Holloman AFB had a missile range extending 64 mi. north and south and 38 mi. wide. In 1952, integrating with Army's White Sands Proving Ground just to the south of the Holloman Range, extended the range to 100 mi. long and 40 mi. wide. Now known as the White Sands Missile Range (WSMR) it serves the Army, Navy and Air Force, with executive responsibility for operation of the range vested in the Army.

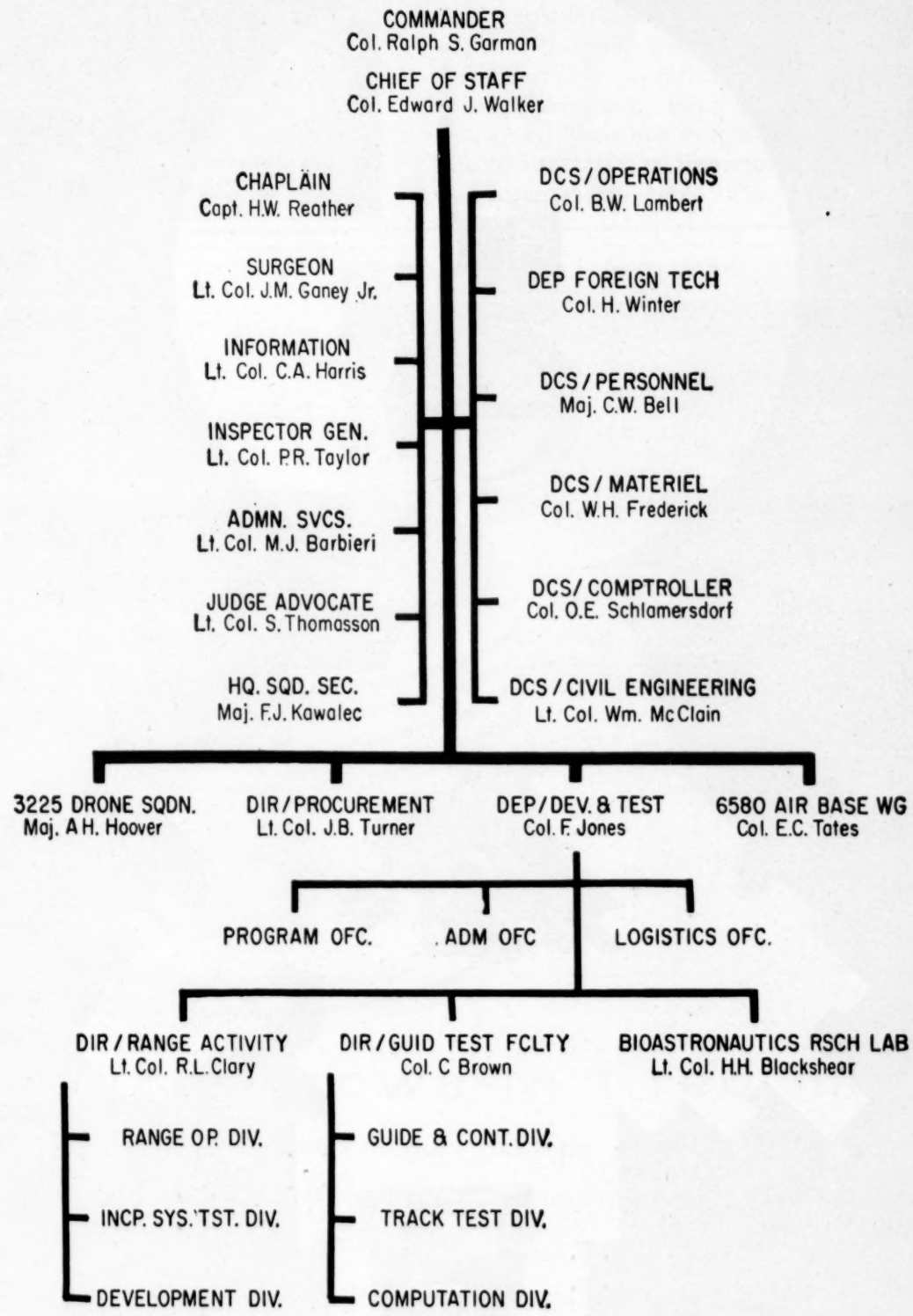
A most highly instrumented piece of real estate, the White Sands Missile Range now has 1,178 instrumentation sites, including:

- **80 cinetheodolite sites** to obtain missile trajectory information.
- **37 telescope stations** to obtain missile track data.
- **20 ballistic camera** stations.
- **8 FPS-16** long-range, precision accuracy radars to track and control the reentry and landing of space vehicles.
- **Many electronic stations,** including telemetry, doppler velocity-acceleration profile, velocimeter, communications and radar.

A unique Holloman facility is the 35,000 ft. high-speed test track designed to test complete missile weapon systems and components as well as conduct research in aeromedical problems, aerodynamic stress, acceleration, deceleration, vibration, instrument checks and other conditions connected with actual space flight.

The other facility is the stratosphere chamber. Temperatures from −100 deg. F to 200 deg. F test both human and mechanical specimens within the 8 x 8 x 11 ft. chamber. Sequences of varying combinations for vibration, temperature, humidity, and altitude can be reproduced for all known conditions in space environments and rarefied atmospheres.

Air Force Missile Development Center



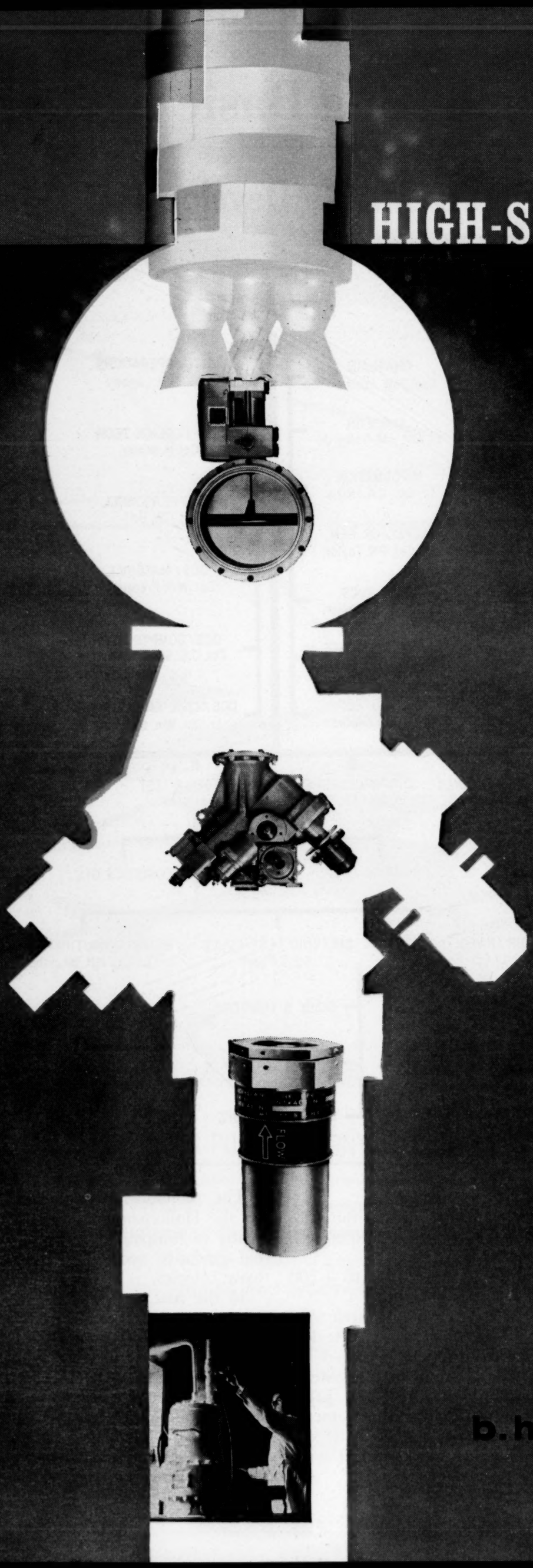
General specifications are:

- **Altitude:** 140,000 ft. in four minutes; 200,000 ft. in 20 minutes; 220,000 ft. ultimate.
- **Temperature:** −100 deg. F. to +200 deg. F.
- **Humidity:** 15 to 90% relative humidity at 33 to 140 deg. F. A dew point of approximately −15 deg. F. is possible by use of an air drying system.
- **Vibration:** Five to 2,000 cps., 5,000 lb.-force, ½ in. maximum displacement.
- **Test Space Size:** Chamber—8 ft. x 8 ft. x 11 ft.-long. Anteroom—4 ft.-wide x 8 ft.-high x 4 ft.-long.

The preponderance of items tested on the Holloman track has shifted recently to components used in the inertial guidance systems of ICBMs and space vehicles.

In the past, development of a guidance system has been accomplished in two steps: laboratory testing of components and system, and flight testing of the complete system. This method had been adequate for aerodynamic or short-range ballistic missiles, but with requirements for longer ranges or extended operation time, new design and test approaches are required to assure

HIGH-SPEC HARDWARE for



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For example [illegible] to 24" diameter [illegible] very low pressure [illegible] from −423°F to +500°F [illegible] handle liquid [illegible] LN_2, Helium Gas, RP-1, JP-4 fuels, UDMH, [illegible] . . . open and close in 0.1 second . . . are actuated by pneumatic cylinder, electric motor, pressure cartridge and manual (including servo-positioning). The hermetically sealed 4-inch butterfly valve (left) has a 1 psiΔ P @ 1100 gpm flow.

Hadley pneumatic regulators handle Oxygen, Nitrogen, Helium, Air and other gasses . . . control pressures within a band of less than 1% of set downstream pressure with inlet pressure decaying 97.5% and gas temperature increasing 550°F . . . available in type O and type I control mechanisms . . . sizes 1" to 12". Helium pressure regulator and shut-off valve (left) is one of nineteen Hadley controls being used on a single missile.

Hadley pneumatic and hydraulic check valves, available up to 6" I.d., operate at pressures up to 6,000 psig . . . at temperatures from −423°F to +450°F . . . handle Helium, GN_2, Air, Oxygen, RP-1, JP-4 Fuels, liquid oxygen, LN_2. The [illegible] check valve (left) — part of an ICBM helium pressurization system — has a flow capacity of 30 lb/min at 180 psig inlet . . . weighs .6 pounds.

These are typical examples of the hundreds of Hadley fluid controls . . . designed to specification . . . value-engineered for reliable performance at low cost . . . thoroughly checked in extensive in-plant test facilities. So, if your concern is hard-to-handle fluids under precise operating conditions, check Hadley first. Write for Data File AW-1097-1.

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necessary system accuracy. Errors which were once considered neglible now are significant factors in the system design and evaluation.

Each industrial developer of inertial guidance systems or components has his own test facility, equipment and laboratory test procedures, some of which by no means standard or complete.

The modern missile which demands extremely precise gyros and accelerometers requires a standardization and advanced test capability to supplement the normal testing done by the developer.

Test Agency

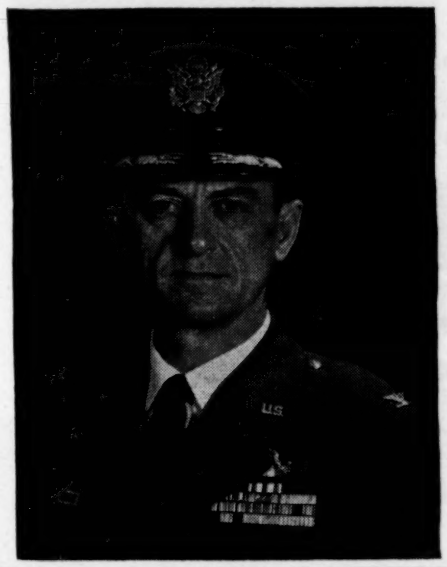
To that end the Central Inertial Guidance Test Facility (CIGTF) was established at AFMDC as an independent testing agency within the Air Force with the mission of "providing a USAF capability for standardized development testing of guidance and control systems and components and to provide numerical evaluations on basis of which the responsible governmental agencies can make development decisions."

To accomplish this mission, CIGTF requires that engineering or prototype guidance and control systems be processed through the following phases of the test and evaluation cycle:

- **Laboratory testing:** divided into gyro tests, including tumble tests, servo tests, linear vibrator tests and environment tests; accelerometer tests, subdivided into constant gravity field tests, sinusoidal vibration tests, constant "g" centrifugal tests and environmental centrifugal tests; computer tests wherein inputs from the inertial measurement unit can be played through the computer and the output checked, and system tests which include static and environmental investigations to determine the system's performance parameters with accurately controlled inputs.
- **Environmental testing:** investigations of gyro and accelerometer performance deterioration due to temperature, altitude and vibration environments.
- **Sled testing:** evaluation of the system under a sustained linear acceleration and high-frequency vibration as well as obtaining gyro and accelerometer error coefficients.
- **Flight testing:** data-reduction and quantitative analysis of flight tests conducted at Patrick AB or Vandenberg AFB.

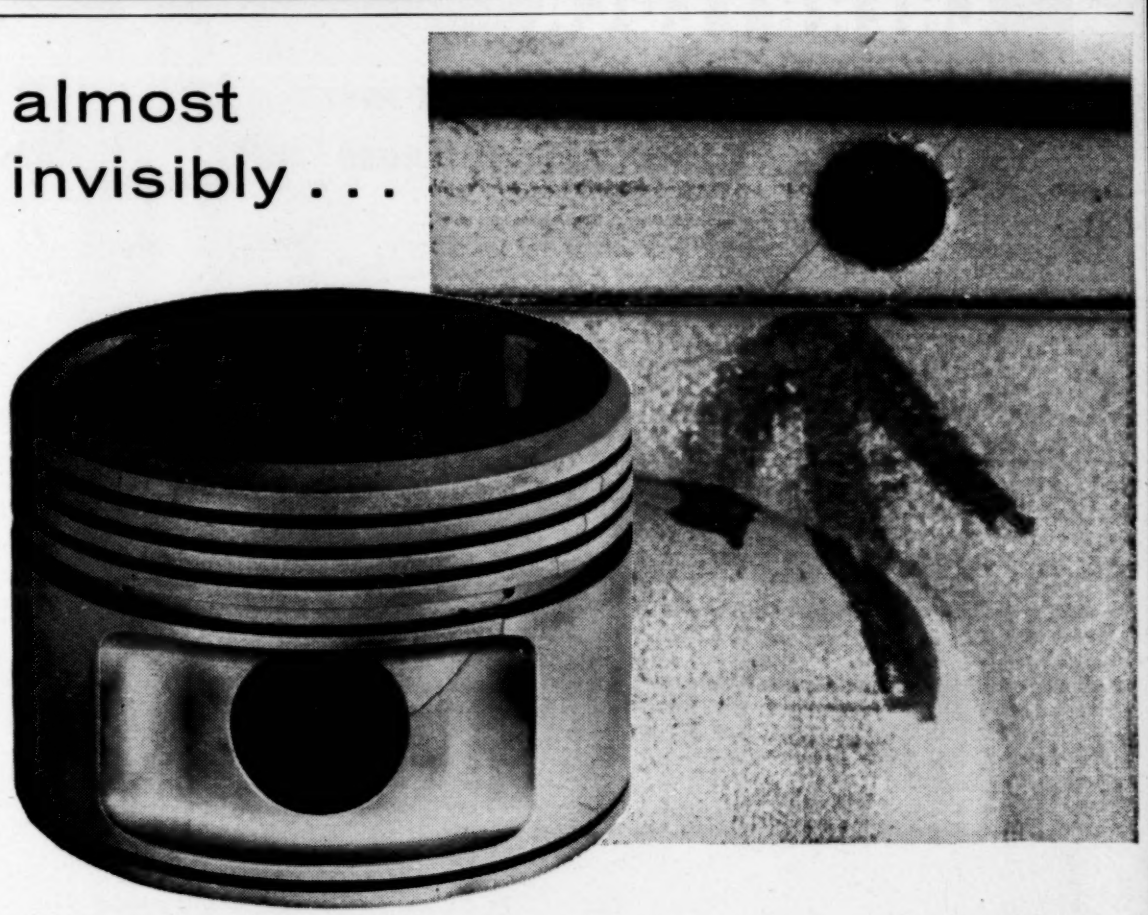
Bioastronautic Research

The Bioastronautic Research Laboratory at AFMDC is continuing the study of man's ability to adapt himself to space flight that first started at Holloman AFB in 1949 with the use of mice and monkeys as 'piggy-back' passengers



Colonel Ralph S. Garman, Commander, Air Force Missile Development Center, AFSC . . . born Bruce Lake, Ind., 1912 . . . Associate in Arts degree, 1933 . . . flying cadet, 1938 . . . service with 1st Pursuit Group . . . combat duty in England and North Africa . . . assistant chief of the Aircraft Branch, Research and Development Directorate . . . assistant chief of Weapons Components Division, Wright Air Development Center . . . director of requirements/Operations, Hqs., FEAF, 1955 . . . chief, Plans and Programing, Hqs., Sacramento AMA to Inspector General, Hqs., Sacramento AMA, 1956.

almost invisibly . . .



trouble grows in tired metal

The enlarged piston section at the right has a fatigue crack. It is almost invisible to the naked eye, even though an etch treatment has been used to make cracks easy to see. If the inspector doesn't spot this crack at overhaul, it will grow and become as dangerous as the one in the piston at the left.

Airwork uses two separate methods of piston crack determination; (1) etching treatment, followed with a binocular microscope of the critical areas, (2) Zyglo inspection. We have some of the most extensive black light inspection facilities in the East.

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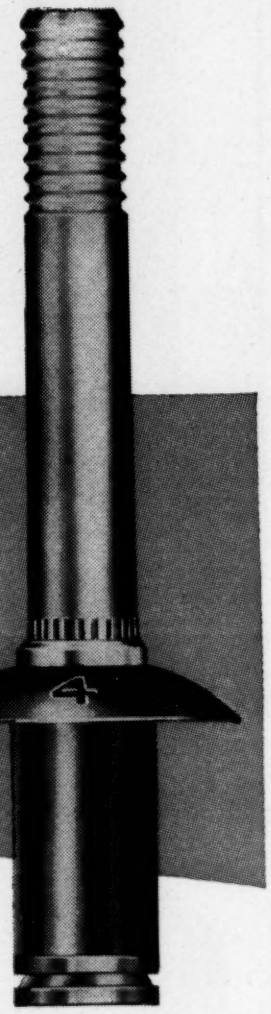

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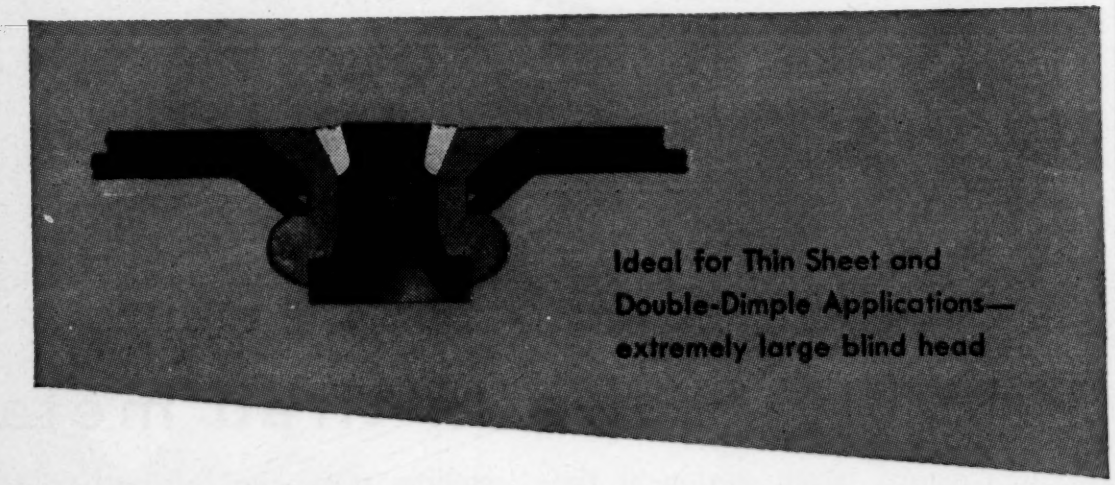

The Bulbed Cherrylock* offers a blind rivet that installs and performs like a solid rivet. Bulbed Cherrylock Rivets will qualify where you are now using solid rivets, offering higher joint strength with greatly increased joint reliability under critical loading conditions—fatigue, shake and sonic vibration.

Now Cherrylock rivets give you a blind rivet that can be used in expensive forgings as well as for joining and attaching sheets and components.

For technical data on Cherrylock Rivets, write Cherry Rivet Division, Townsend Company, Box 2157N, Santa Ana, California.

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* Patent Pending

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carried in the nose cones of rockets.

The tolerances of man to acceleration, noise, vibration, buffeting, oscillation, atmospheric composition, toxic gases, noxious odors, nutrition, hydration, day-night cycle, boredom, etc. have been the subject of numerous tests conducted in the stratosphere chamber, the 120-ft. decelerator and the sled track, as well as aircraft, balloons and rockets. Man's physical reaction to these stresses have been well analyzed and are believed to be understood. Still under study, however, are the physiological and psychological behaviorism of man in space when confronted with all the problems enumerated before plus the stress of anxiety, complete isolation and detachment for long periods of time. In view of the fact that these numerous hazards had never been evaluated simultaneously and no information about their combined impact was available, experimentation with animals, in strict compliance with the rules of the American Medical Association, was resorted to.

Animal Colony

For this purpose, the laboratory maintains an extensive animal colony, which presently is comprised of 52 chimpanzees.

The second agency which is concerned with the behavioral effectiveness of the animal is the Comparative Psychology Branch of the Bioastronautics Research Laboratory. Its main effort consists of adapting equipment for measuring animal behavior in the laboratory for use in the space vehicle and developing models for the type of behavior which will be measured during space flight.

Trained to perform simple tasks such as the manipulating of levers or pressing buttons under controlled circumstances, the behavior of the chimps in space flight can be associated and identified with the behavior of man in similar circumstances. Further, it is assumed that if the animal suffers no deleterious physiological effects as a result of exposure to space environment, it will be safe for man, also.

Project Mercury

In readying the animals for participation in proposed space flight programs, the Bioastronautics Laboratory must be able to tell the capsule designers and engineers exactly what the animal will do at least 10 months before a flight is actually scheduled. In the case of Project Mercury, it was 14 months before the time of first flight. In these programs, limitations are usually imposed relative to weight range and size of the chimpanzee to be used to conform to the configuration of the capsule. These factors require that training start

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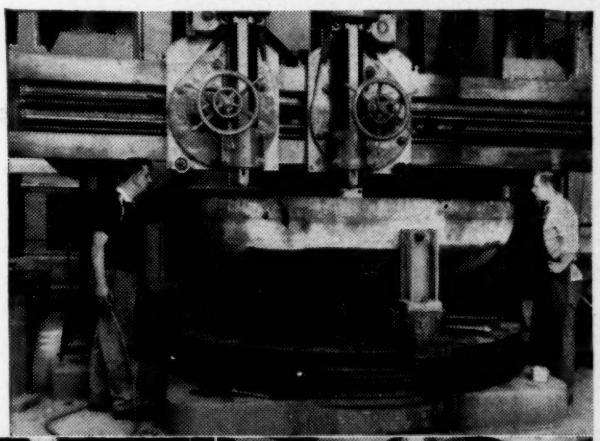
• • • like these huge solid rocket motor components for **GRAND CENTRAL ROCKET CO.** . . . under sponsorship of the Air Force Flight Test Center, Edwards AFB, California.

Machining 120" Big Booster Heads



RV-A-10 • Sergeant • Air Force — Re-Entry X-17 • Polaris — Re-Entry X-36 • Jupiter Jr. • Jupiter Sr. • Polaris O • Polaris A • Polaris AIX • Polaris A2-MOD 1-2-3 • Nike Hercules • Nike Zeus • Minuteman • Pershing • N.A.S.A. Programs • Scout • Little Joe and now — **Big Solid Boosters.**

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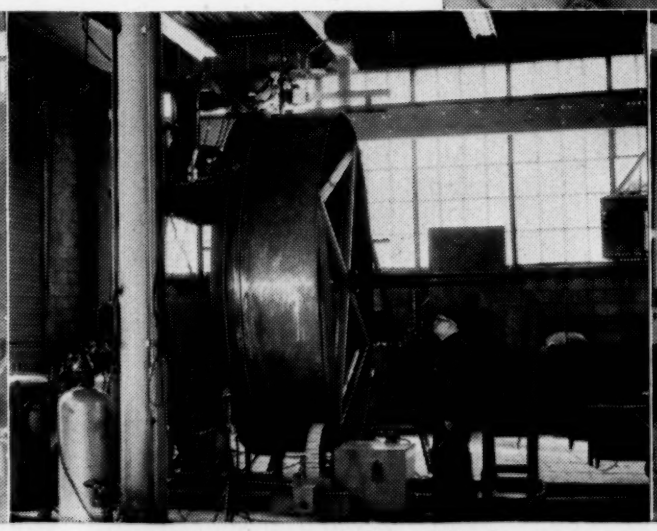
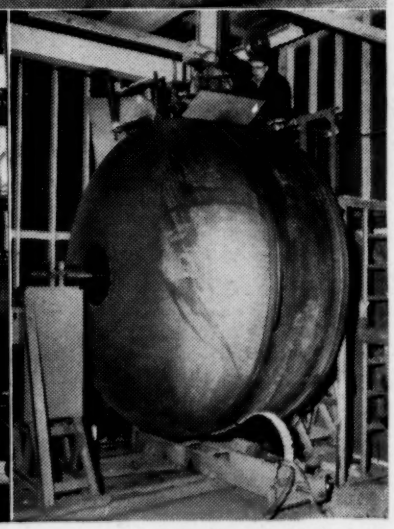


Special Automatic Welding of Big Booster Head Assemblies



Big Booster Automatic Welding

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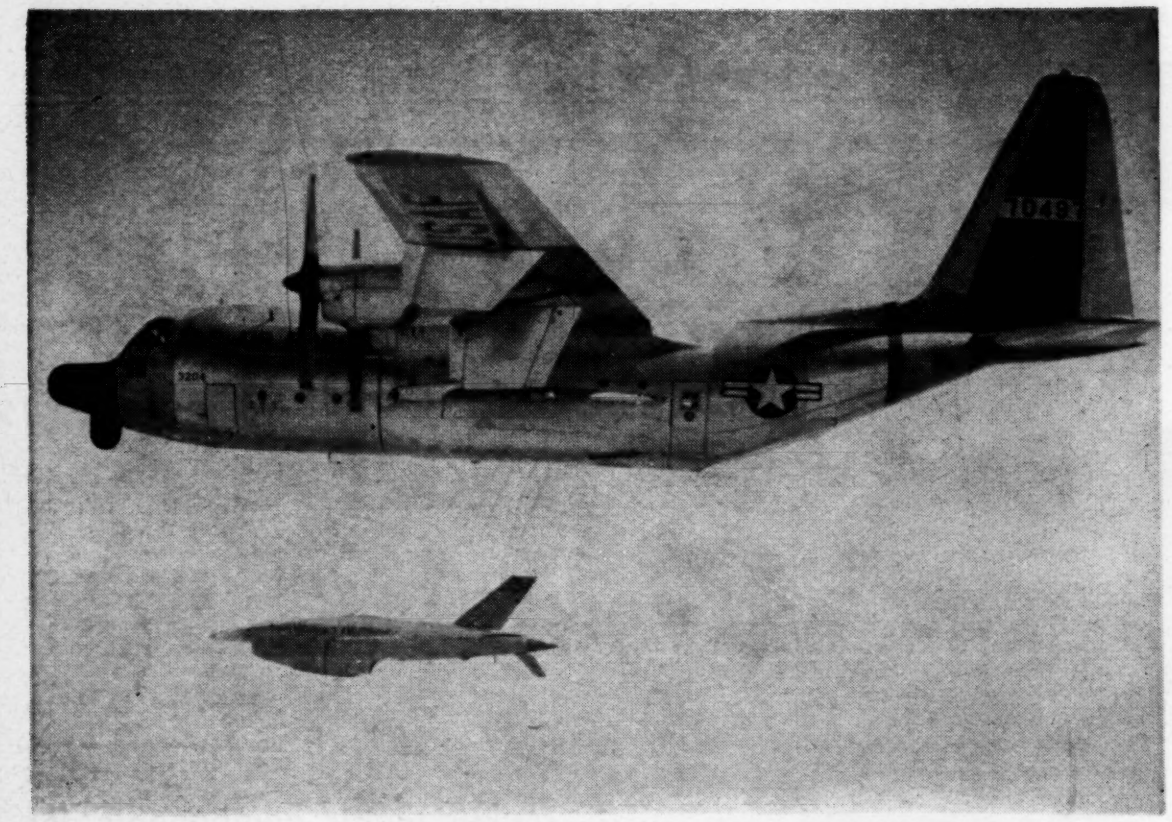


LOCKHEED GC-130A launch of Ryan Q-2C drone at White Sands Missile Range.

with a small animal to ensure it will not outgrow the capsule by firing time. Three animals outgrew the Mercury capsule. The success of the flight with the chimpanzee "Ham" is a tribute to the research and training initiated at Holloman.

Associated Activities

Associated with the activities of the Air Force Missile Development Center are four major areas of endeavor which contribute to the accomplishment of the mission of Holloman AFB. They are:

- **Range Operations Division**
- **Interceptor Systems Test Division**
- **Balloon Operations Branch**
- **Missile and Drone Branch**

The Range Operations Division which is responsible for all Air Force missions whether they be generated from Holloman, Kirtland AFB, Edwards AFB or Eglin AFB has four major areas of responsibility:

- **Scheduling** of Missions
- **Control**
- **Operational** Safety
- **Records** Compilation

Interceptor Systems

The Interceptor Systems Test Division is assigned the responsibility of testing complete interceptor weapon systems, is subdivided into the following five branches:

- **Test Operations** schedules missions.
- **Weapons Branch** evaluates and assists missile development and tests.
- **Systems Engineering,** with its two sections, MA-1 and MG-10/13, evaluates and reports on fire control system development and tests. It also monitors the integration of the requirements of the other branches.
- **Electronics Countermeasures** provides the theoretical laboratory and in-flight simulation for electromagnetic vulnerability testing of the complete weapon system.
- **Flight Loads Branch** evaluates and reports on airframes and aerodynamic development and tests.

The present efforts of the division are directed toward three distinct development and test programs.

- **F-106 Service Revealed Deficiency Program.** Two highly-instrumented F-106 aircraft are testing refinements to the fire control system such as: (1) The pursuit attack mode, originally designed in the fire control system but not completely investigated during earlier development test programs because of emphasis toward perfection of the primary lead collision attack mode. Development and qualification of the pursuit tactic will permit the continuation of attack, and the capability to fire all armament, at any time a malfunction of the primary system exists, or the tactical situation demands a pursuit intercept. (2) Greater fire control system capability for low altitude radar acquisition and lock-on. This has resulted not only in refinements to the fire control system, but has generated pilot hand-control techniques under turbulent air environments. (3) Improvement in the aerodynamic and guidance system reliability of the GAR-4A infrared missile under high dynamic pressure environments. Along with this refinement went tests to improve the acquisition and retention when tactical situation demanded firing against a sun background or a missile wide-look angle prior to firing.
- **Interceptor Improvement Program.** A development test of five major modifications to the fire control system incorporated in the F-101 and F-106 and one modification to the F-102 fire control system. One of the five modifications to the F-106, F-102 and F-101 will establish an infrared sight capability for target acquisition and attack presentation within the respective fire control systems. The other modifications will be incorporated in the F-101 and F-106 only and will include state of the art refinements to enhance the radar and decrease electromagnetic vulnerability while operating under tactical situations.
- **MB-1 Genie Modification Program.** Operational firing test of the feasibility and capability of a major Genie modification.

Missile Branch

The Missile Branch at Holloman conducts and supervises six different projects on WSMR.

The six projects are:

- **Mace TM-76A** guided missile
- **QTM-61 Matador** drone program
- **T-33 simulated missile** for evaluation of ATRAN guidance system.
- **GAM-77A Hound Dog** missile
- **Mace** launch team training.
- **Arcas-Robin** high altitude research rocket.

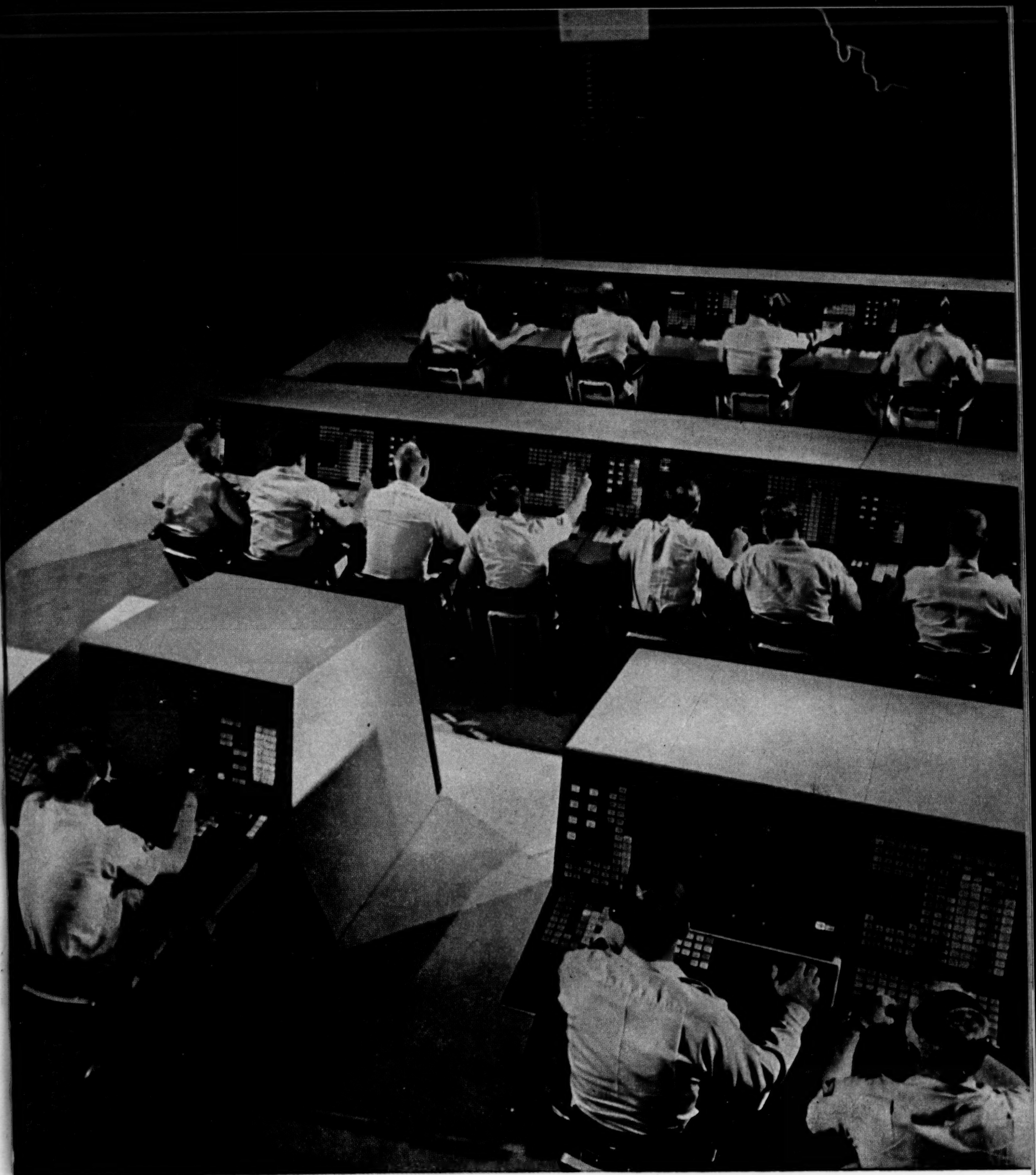
The Missile Branch is also conducting a feasibility study of launching, on the White Sands Range, a Blue Scout, now being launched at Cape Canaveral and Wallops Island, both over-water ranges. There is a need for the data-gathering resources of the land range at Holloman AFB. The Branch hopes to begin Blue Scout operations in January 1963.

Drone Branch

The Drone Branch of the Missile Development Center is responsible for the development of aerial target drones and their associated support and augmentation systems.

The drones now being tested at Holloman are the following:

- **Q-2C,** a high altitude, Mach .9 target drone developed by the Ryan Aeronautical Co. of San Diego, Calif. and powered by a Continental Aviation Co. J-69-T-29 turbojet engine with a thrust of 1,750 lbs. The Q-2C may be either air-launched or ground-launched when equipped with an Aerojet-General 11,000-lb.-thrust, solid propellant booster motor.
- **Q-4B,** a high altitude, supersonic (Mach 2) target drone developed by Radioplane Div. of Northrop Corp., Van Nuys, Calif. It is powered by a General Electric YJ-85-5 turbojet engine producing 2,450 lb.-thrust and 3,600 lb.-thrust with afterburner. It is equipped with the Microwave Command Guidance System developed by the Sperry-Phoenix Co.



AIR WEAPONS CONTROL SYSTEM, 412-L Systems, fixed site center prototype.

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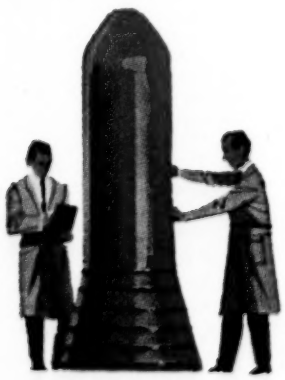
THE BIGGEST PLASTIC ROCKET NOZZLES ARE FROM HITCO

Coming... rockets that will dwarf—in size and thrust—every preceding launching. The plastic components that will gird them for flight will be manufactured to standards only recently considered impractical.

The Dumont Division of HITCO has advanced the art of molded plastics to this capability in the brief period of four years. Now, under HITCO, a combined team of engineers and technicians has made technological breakthroughs in both insulative and ablative plastics. New tooling techniques have been developed; the Dumont hydroclave can put pressure of up to 6500 psi uniformly on the surface of a reinforced plastic part. Dumont and HITCO are currently molding rocket engine components at pressures up to 30,000 psi.

Though giant rockets are still in the planning stage, the *giant plastic capabilities are here today*. HITCO is ready *now* to fit the biggest rockets with the biggest plastic nozzles.

HITCO-developed ablative materials and fabrication techniques are also providing Atlas and Titan nose cone heat shields. These materials enabled the first ICBM nose cone recovery.



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DUMONT MANUFACTURING CORP. *A Subsidiary of H. I. Thompson Fiber Glass Co.*
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WRITE OR CALL YOUR NEAREST HITCO FIELD ENGINEER. EASTERN: Tom Kimberly, 38 Crescent Circle, Cheshire, Conn., BR 2-6544. Fred W. Muhlenfeld, 6659 Loch Hill Rd., Baltimore 12, Md., VA 5-3135. MIDWEST AND SOUTH: Burnie Weddle, 5650 Colton Dr. N.E., Atlanta 5, Ga., Phone 255-7804. SOUTHWEST: Marshall Morris, 2850A W. Berry, Rm. 7, Fort Worth, Tex., WA 4-8679. SAN DIEGO: John Veil, 9048 Haveteur Way, BR 8-5350. SACRAMENTO: Raymond Cutler, 4411 Surita St., IV 3-7243. CANADIAN PLANT: THE H. I. THOMPSON CO. OF CANADA LTD., 60 Johnston St., Guelph, Ont., TA 2-6630.

Circle Number 238 on Reader-Service Card

Command & Control Links USAF Forces

Electronic Systems Division develops systems that gather, filter and present data for command decisions.

Hanscom Field, Mass.—Electronic Systems Division holds a major portion of the responsibility for developing the "truly unified, nation-wide, indestructible system to assure high-level command, communication and control and a properly authorized response under any condition," which President Kennedy has called a vital objective for national survival.

There is a striking parallel in nature. To survive in a hostile environment, animal life has had to develop eyes, ears and other sensors to warn of impending danger, a nervous system to provide rapid communications and a central brain for making fast decisions, all operating as an integrated "command and control system."

The Electronic Systems Division (ESD) here faces the staggering problem of welding together a far-flung collection of diverse warning sensors and weapons into what is, in effect, a single weapon system whose trigger is always cocked but "on safe," always within reach of an authorized finger but never to an unauthorized one.

Many of today's concepts in command and control systems can be traced back to the SAGE air defense system. When it was first conceived a decade ago, its dozens of radar sensors, digital computers and communications networks seemed the ultimate in sophistication and complexity.

Today, SAGE pales alongside the complexity of a unified Air Force command and control system, let alone a national one. The vast network of Air Force radars designed to detect air-breathing vehicles has recently been joined by the ballistic missile early warning system (BMEWS). This ICBM warning capability may soon be expanded through the use of orbiting Midas satellites.

Additionally, the prospect of military space vehicles intended for offensive operations creates the need for surveillance of the vast reaches of space.

Integration of these many different types of warning sensors and correlation of their output to increase reliability and enhance the credibility of their warning is one of Electronic Systems Division's most challenging problems today.

Changing Environment

The fast-changing nature of nuclear weapon delivery systems creates additional problems. In addition to maintaining reliable communications for control of a far-flung airborne bomber force, there will be hundreds of ICBM launch sites widely dispersed around the country. Communication links to each of these sites must be designed to withstand an initial nuclear blow.

Because decisions crucial to the life of this and allied nations may have to be made in a scant 15 minutes, or less, most of the new command and control systems are built around large digital computer/data processing machines. These are intended to collate, filter and store vast amounts of rapidly changing input information for display to top decision makers.

Major General Kenneth P. Bergquist, ESD commander, emphasizes that electronic command and control systems must be the servant of military decision makers, and not the reverse. They must provide him with the means for better planning and quicker, more knowledgable decisions. The systems must be flexible and easy to use, Bergquist says.

Additionally, a command and control system must include provisions so that a military commander can "exercise" the weapon systems in simulated war games in peacetime.

Man-Machine Interface

In one sense, command and contol systems represent the interface between essentially unchanging human beings and rapidly changing weapon systems. This requires that ESD personnel not only be masters of a variety of electronic techniques, but that they also have a deep insight into the thought and reaction processes of the human mind, together with an understanding of military strategies, tactics and weapon system capabilities.

Where formerly the emphasis within Electronic Systems Division and its predecessor organizations was primarily on electronic technology, there is increasing emphasis on the man-machine interface and on military strategy. There is a growing influx of military officers from operating commands into key ESD posts, bringing with them a first-hand knowledge of weapon systems and their operational problems.

Brig. Gen. Charles H. Terhune, Jr., ESD vice commander, brings to this division extensive experience in the field of ballistic weapons. Terhune was deputy commander for ballistic missiles at the Ballistic Missile Division from June 1954 until May 1959.

Hanscom Complex

Within a radius of several miles of ESD headquarters here at Hanscom Field is the largest collection of scientific manpower engaged in research, development and management of command and control systems in the Western world and probably on the face of the globe. It is frequently referred to as the Hanscom Complex and includes:

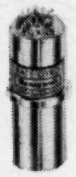
- **The Mitre Corp.**, a non-stock, not-for-profit company with a staff of about 450 professional engineers and scientists supported by a like number of technicians. Chartered three years ago to provide the United States government with technical advice in command and

Maj. Gen. Kenneth P. Bergquist, Commander, Electronic Systems Division, AFSC . . . born Crookston, Minn., 1912 . . . graduate U. S. Military Academy, 1935 . . . completed pilot training 1936 . . . deputy to Asst. Chief of Staff/Operations in Army Air Forces Hqs., Washington . . . military air attache in Athens during Greek-Communist war . . . National War College, 1949 . . . duties with Air Defense Command until 1955 . . . Assistant Deputy Chief of Staff/Operations, 1957 . . . first commander of Air Defense Systems Integration Division at Hanscom Field, 1958 . . . commander of Command and Control Development Division, 1960.

INERTIAL COMPONENTS

SUB-SYSTEMS AND FLIGHT TEST EQUIPMENT

RATE GYROSCOPES



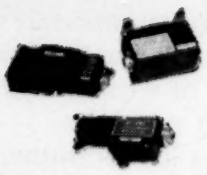
TYPE M-100 is the latest in Honeywell's family of miniaturized high performance rate gyros. It features constant damping over a wide operating temperature range (−65°F to +250°F) without the use of heaters.

TYPE GN or "Golden Gnat" is another of Honeywell's high performance gyros and has been in full production in a wide variety of miniature rate packages over the past four years.

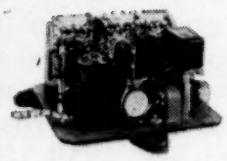
TYPE JR, another rate gyro of proven reliability, features a unique quadrilever spring suspension for high sensitivity and a wide full range under severe environmental conditions; TYPE JRS, with Gimbal Torquer and SMRD self-check circuits plus thermostatically controlled damping system heaters, fulfills requirements for confirmed reliability and constant damping; TYPE K Rate Measuring Gyro features a linear output signal that is proportional to the input rate within 0.25% full scale.

INERTIAL SUB-SYSTEMS

Roll, pitch and yaw rates are measured by special Inertial Sub-System Packages using Honeywell Gyroscopes. The polarity and amplitude of the output D-C signals correspond to input rates of turns. These output signals, teamed with other equipment, make possible uniform pilot control response for all flight conditions.



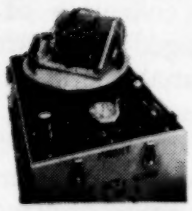
F102 PACKAGE, with three Model JR Gyros, is used in the F102 fighter.



F104 PACKAGE, designed around three Gnat Gyros, is used on the F104 Super Star Fighter.

F106 THREE-AXIS TURN RATE TRANSMITTER also uses three Gnats.

TEST EQUIPMENT



HONEYWELL RATE GYRO TEST SET designed for use by field personnel for the static analysis of rate gyros, rate gyro demodulator amplifier, and three-axis rate gyros packages. This equipment meets the design requirements of MIL-T-945 and environmental test requirements outlined in MIL-E-4970.

SPECIALIZED TEST EQUIPMENT such as Radar Range Servo Test Sets, Frequency Response Analyzers, and other electronic equipment can be designed and manufactured to meet your requirements.

ACCELEROMETERS

TYPES LA-100, LA-300 are low cost, rugged, linear, non-pendulous units with potentiometer outputs.

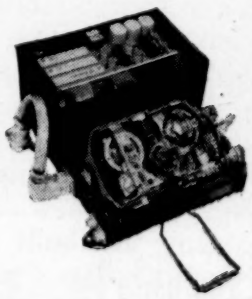
TYPE LA-200 is a miniaturized, pendulous, linear accelerometer which is fluid-damped and mechanically compensated. Output signal is provided by a variable reluctance signal generator.

TYPE LA-500 is a linear, non-pendulous, fluid-damped potentiometer output device that features constant damping, linear response, (−65°F to +175°F).

TYPE LA-600 is a linear, non-pendulous A-C accelerometer in which pick-off friction is eliminated to permit resolution of extremely low level inputs. This accelerometer features magnetic damping for near constant damping ratio (−65°F to +250°F).

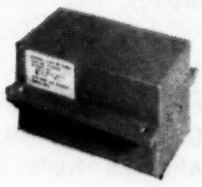
TYPE LA-800 subminiature linear accelerometer is the smallest such instrument available today offering a variable reluctance pickoff and an essentially constant damping ratio over the temperature range of −65°F to +250°F.

CONTRACT ENGINEERING AND MANUFACTURING



Honeywell's Boston Division will design from customer specifications or prototypes, or manufacture to customer's drawings. Typical of the completed programs in this area are: CN-100 Compass-controlled Stable Reference Platform for a bombing system (shown at left), and Displacement Gyros for the A1A/BNC Bombing Navigational Computer.

MARK 46 PACKAGE, containing three Gnats plus two pendulous accelerometers, supplies complete stabilizing data for the automatic pilot on the Mark 46 Torpedo.



POLARIS PACKAGE, with three Gnats and associated circuitry in a 5⅛" x 4" x 2 15/16" package, is the control rate of turn instrument in the Polaris Missile.

Write to Minneapolis-Honeywell, Boston Division, Dept. 2, 1400 Soldiers Field Road, Boston 35, Massachusetts.

Honeywell

Military Products Group

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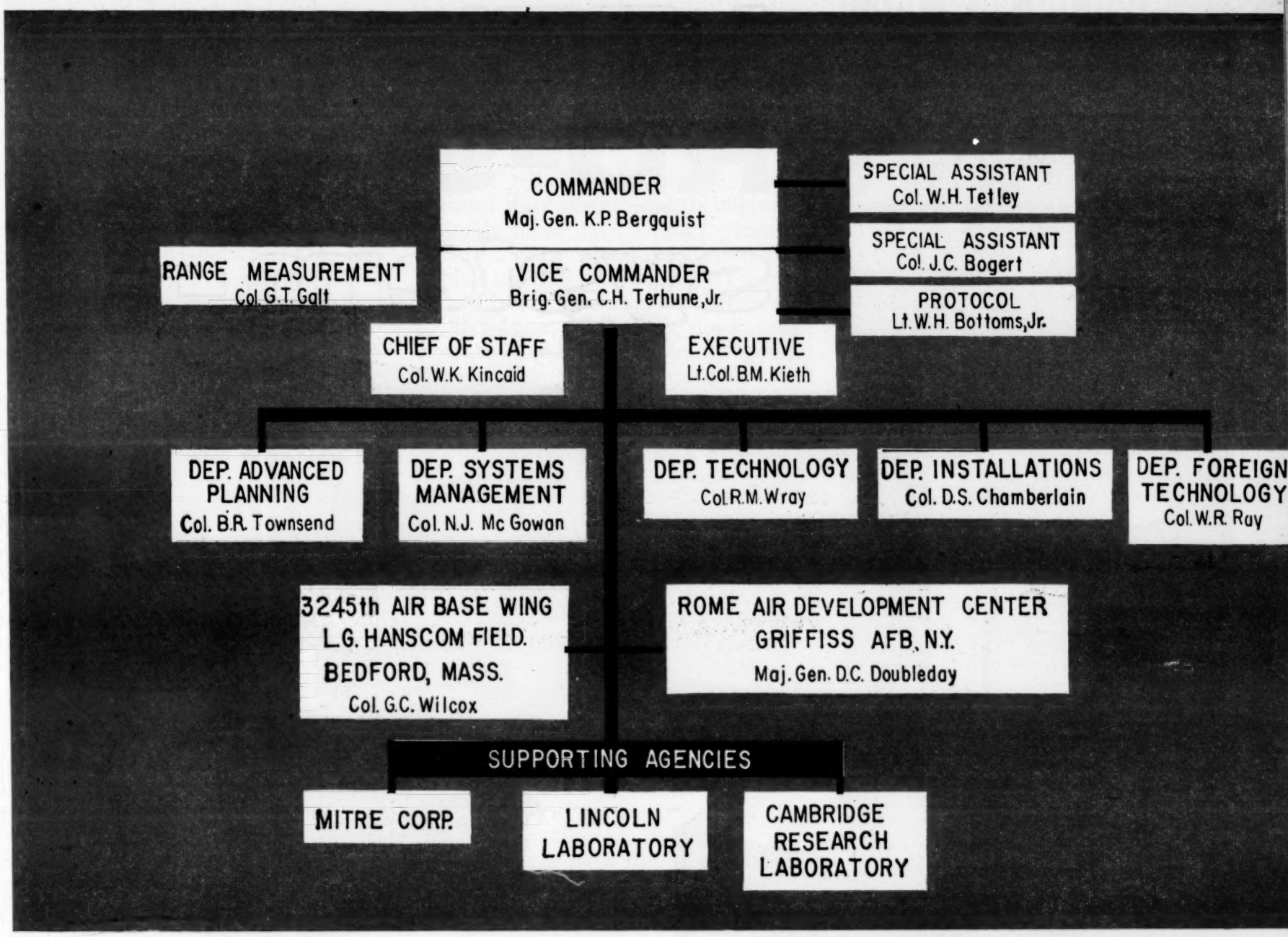


ELECTRONIC SYSTEMS DIVISION ORGANIZATION

control, Mitre's principal effort is providing ESD with advanced system analysis and planning for new systems, inter-system integration and general systems engineering.

• **Lincoln Laboratory,** a tri-service sponsored facility with approximately 600 engineers and scientists which carries on basic and applied research in radar, communications and data processing.

• **Air Force Cambridge Research Laboratories,** reporting to the Office of Aerospace Research (not ESD), has approximately 550 scientists and engineers working in basic and applied research in geophysics and electronics.

Lincoln Laboratory and Air Force Cambridge Research Laboratories are located here at Hanscom; Mitre is several miles away in Bedford, Mass.

The Rome Air Development Center is not a part of the Hanscom complex in a geographic sense, but is a part of ESD and serves as its research and development laboratory and engineering support center. RADC, located at Griffiss AFB in New York State, employs about 1,600 people. About 700 are engineers or scientists.

Within the Electronic Systems Division today are all of the missions previously assigned to the former Air Research and Development Command's Command and Control Development Division (CCDD) plus many of the functions of the former Air Materiel Command's Electronic Systems Center, both located here. The CCDD had been created early in 1960, at the time of the last major ARDC reorganization, to assume and expand the mission previously performed by the Air Defense Systems Integration Division (ADSID).

The site of ESD on the rim of greater Boston can be traced directly to the Massachusetts Institute of Technology Radiation Laboratory, formed in World War II to perform research and advanced development on the then new technology of radar. As a result, the Boston area became the center of radar technology. Additionally, Harvard University's computation laboratory, headed by Prof. Howard Aiken, was one of the earliest pioneers in digital computers after the war, another vital element of command and control systems.

Total personnel assigned to Electronic Systems Division is about 5,800.

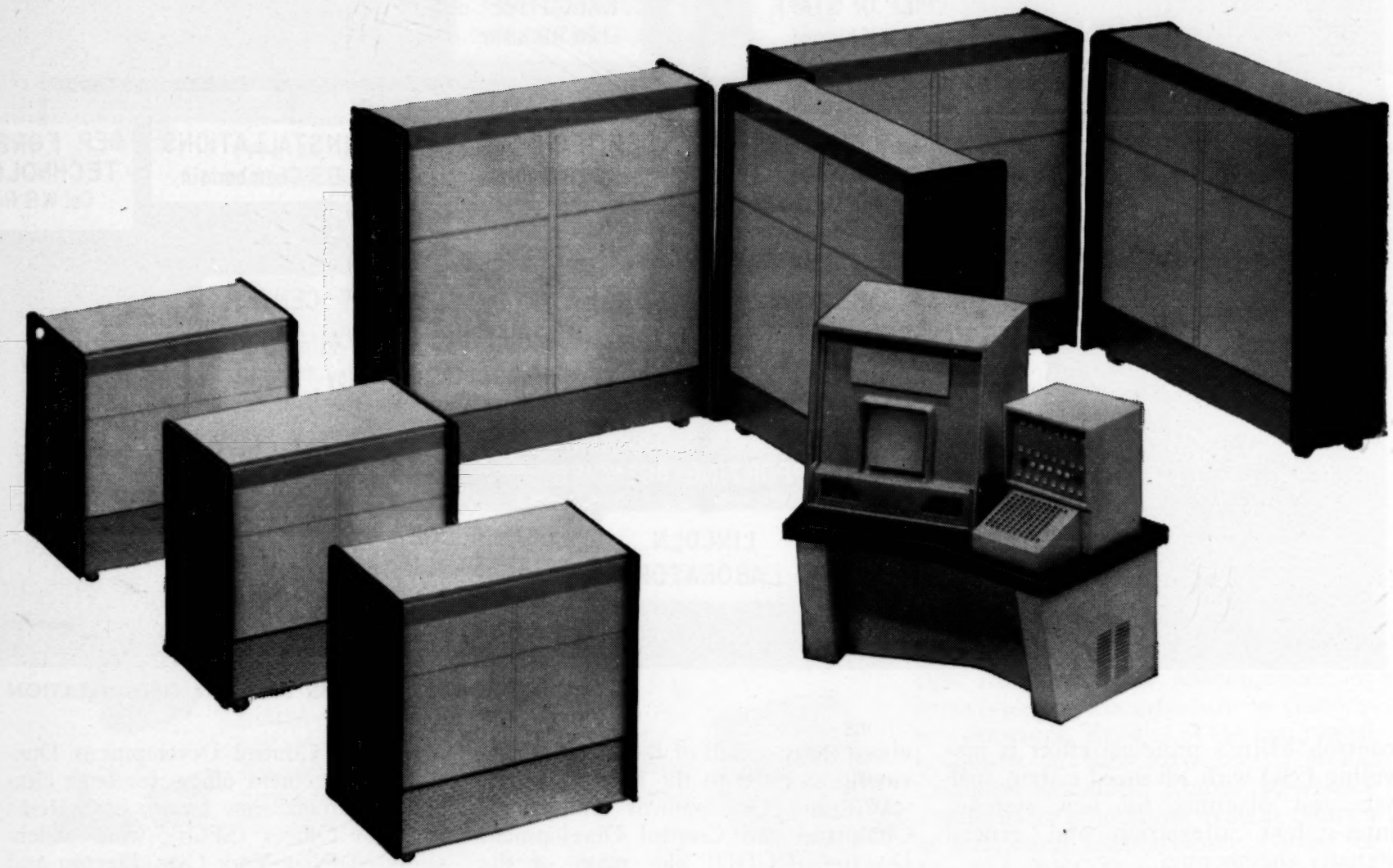
Until the formation of the Command and Control Development Division, management offices for large electronic systems, now known as Systems Program Offices (SPOs), were widely scattered—New York City, Dayton and Hanscom Field. With the formation of CCDD in 1960, all these SPO's were relocated here.

At the time it was thought that the major problem was one of technical integration of these systems, frequently referred to as "L-systems" because their numerical designation ends in "L," a symbol used by Air Force to denote all support (non-weapon) systems. For example, assuring that digital computers in one system could communicate with machines in another, or employ the same communication links was thought to be the most pressing problem.

But once the centralization had occurred, it was recognized that a more basic need was "functional integration", such as determining how the function of one L-system impinged upon another and how data in one system might be used by another.

Previously, L-systems had been developed to meet a specific operational need of a single command, such as

LFE's new RD-900 system--



. . . provides a random access file of up to 495 million bits with access to information in less than 3/10 of a second.

. . . may be operated with all standard general purpose digital computers, or as an independent storage, access and display system.

The RD-900 Random Access Storage and Display System, consists of from 1 to 33 high density, magnetic, file drums, each with a storage capacity of 15 million bits. A Symbol Generator converts coded characters into a visual message as fast as they are read from the file. One Symbol Generator is used to drive any number of output display devices. These include 21″ console displays and large screen projection displays . . . each capable of displaying up to 12,800 characters, symbols or a composite of both. In addition to alphanumeric characters the system can display arbitrary or abstract symbols, schematic or logical drawings, graphs, charts, and maps. Applications include military and industrial systems where information retrieval and display must be simultaneous for instant decision making. For a complete description and specifications write Dept. 101.

LFE

COMPUTER PRODUCTS DIVISION

LABORATORY FOR ELECTRONICS, INC.

1079 COMMONWEALTH AVE. • BOSTON 15, MASSACHUSETTS

Circle Number 274 on Reader-Service Card

SAGE for air defense. Now it became apparent that a much broader viewpoint was needed. For example, the first warning of an enemy air/missile attack, and estimates of likely targets, is of importance to many decision makers: NORAD, Strategic Air Command, the Joint Chiefs of Staff, and the President.

In an age of unrecallable ICBM's, the credibility of warning systems must be increased by a large factor. One way to obtain increased credibility is to cross-correlate the data from a variety of different types of sensors in different L-systems.

During the next several years this will be a high-priority effort for ESD as it seeks to increase the integration of information from BMEWS, from the Space Surveillance System (496-L), from Midas satellites, and from the new Nuclear Detection System (Nudets), identified as 477-L, whose development will begin soon.

But the effort at functional integration will not end here. ESD's advanced planners are working to define conceptually what is termed the "Aerospace Control Environment," or ACE for short. This seeks to establish all of the possible command and control functions that may be required during the next decade, viewed from the top of the command structure rather than from the bottom of the pyramid as in the past.

Fundamental Criteria

One of the fundamental criteria for the Aerospace Control Environment is that it must permit duly constituted authority to react to an enemy threat in a deliberate and discriminating manner, with a response that is swift and effective.

Furthermore, the system must be responsive to a flexible strategy which allows the commander to select one of many courses of action, based upon accurate information presented to him. An enemy would make his initial nuclear attack an all-out one, to wipe out our retaliatory capability, or it is conceivable that the initial attack might consist of only a few weapons followed by a barrage of propaganda and blackmail threats.

The staggering amount of information of possible interest to a commander frequently requires the use of automatic data processing equipment to extract only the most significant information, and to give the decision maker rapid access to information he desires.

However, a fascination with automation can lead to unwieldy and unreliable systems and can flood the decision maker with interesting but unusable information if carried too far.

Recent tests by experimental psychologists in the Operational Applications Laboratory, under ESD's Deputy for Technology, suggest that we may have gone too far in using data processing equipment to unload human operators of fine-grained detailed information.

These tests suggest that the human operator can digest and handle considerably more data without becoming saturated than previously believed. A human operator working under a moderately heavy load may be better able to handle a high peak load under emergency conditions than an operator whose work load is extremely light under normal conditions.

Survivability Emphasized

There is considerable emphasis in ESD on survivability, both for the decision makers and for communication links by which command decisions are transmitted to combat forces.

The objective is not to make all command and control systems, or all elements of a system, equally survivable; rather, to analyze the function and base its survivability requirements on its mission.

For example, a logistics communication network whose primary function is to operate in peacetime and which is not expected to function during and immediately after an all-out nuclear attack need not have the survivability of vital command and control links which control nuclear delivery weapons.

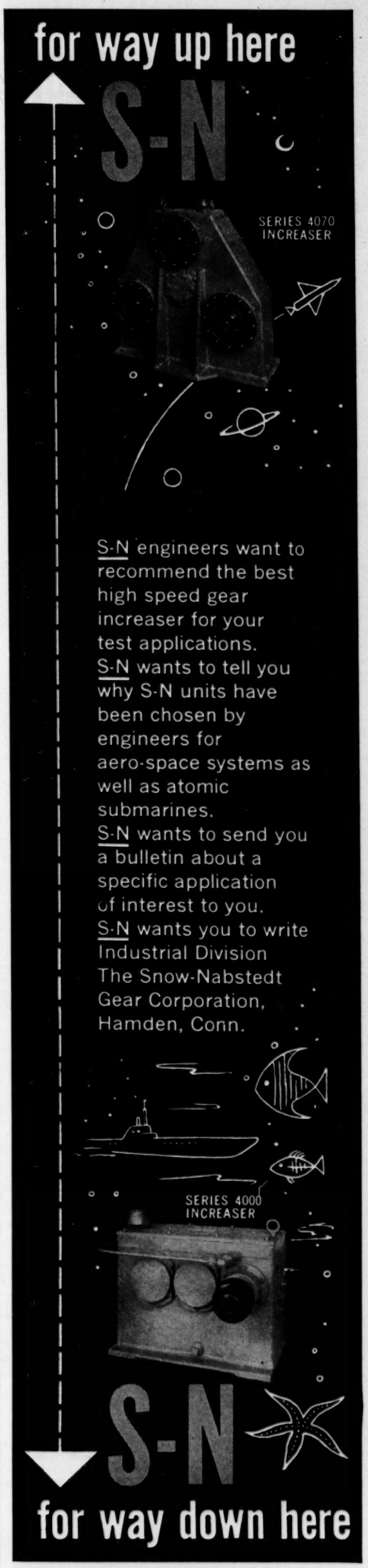
The efforts made to assure survival of a decision maker and his communications should reflect the importance of that decision maker in the command structure.

Within the past several weeks, ESD's Commander, Maj. Gen. Kenneth Bergquist, has announced a major change of procedure in the manner in which new L-system developments will be contracted and managed.

New Philosophy

Where previously an L-system prime contractor was delegated considerable responsibility for system engineering as well as the design and development of the entire system, in the future ESD and The Mitre Corp. will assume more of the system engineering function. First of the L-systems to be developed under this new philosophy will be the NORAD Combat Operations Center (425-L), for which Burroughs Corp. is the prime contractor.

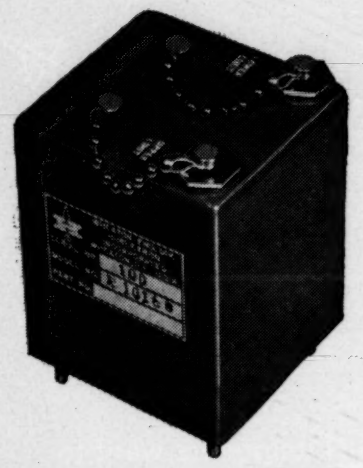
Under the new policy, Mitre will be responsible for systems engineering, technical direction and inter-system integration of new L-systems, working as the technical arm of ESD. The prime contractor role will become a more traditional one of designing and build-



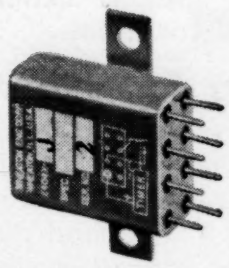
Circle Number 275 on Reader-Service Card

WHEATON ELECTRONIC TIMERS and SENSORS

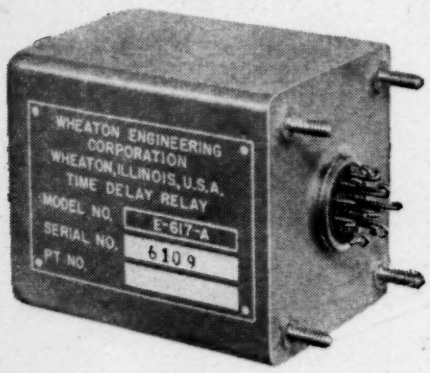
implementing today's space power



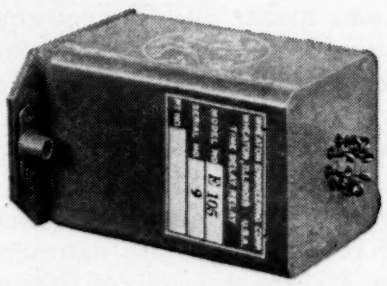
SOLID STATE SENSING: Ferrite core sensors offer high stability and precision, utilizing a completely static operation. Available in fixed or adjustable versions, as well as time delays on pick-up or drop-out. Accuracies of 1%, 2%, 3%, 5% and 10% are standard.



SOLID STATE TIMING: The smallest commercially available complete solid state timer — no larger than a postage stamp. No moving parts. Secures its output function through solid state switching devices. Features a single pole output. Larger units offer multiple output switching logic, and higher current capacities.



ADJUSTABLE TIMING: EXTERNAL: Features an adjusting means within the timer envelope, secured through an "O" ring sealed cover. Adjustment range: 10 to 1. Offers 4PDT 10 amp contact with complete immunity to positive/negative transient voltages. Available in a series of units with time delays from .05 sec. to 2400 sec.



REPEAT CYCLE TIMING: This series of electronic timers repeat a group of timed switching functions with instantaneous resetting, high precision, no warm-up. Operation: two or more timers in "ring" circuit. Completion of one time cycle initiates subsequent units while performing switching functions, repeating until power is removed. Times: milliseconds to hours.

WRITE FOR ADDITIONAL TECHNICAL DATA

WHEATON ENGINEERING DIVISION
Hurletron Incorporated
920 Manchester Road, Wheaton, Illinois

REPRESENTATIVES: W. J. McNABB COMPANY, Box 566, Bellevue, Wash. — SPACE ENGINEERING, 491 N. Las Robles, Pasadena, Cal. — PEM SALES COMPANY, 12861 Chamblee Lane, St. Louis 41, Mo. — REX MAY COMPANY, 2512 W. Mockingbird, Dallas, Texas — M & J ASSOCIATES, INC., Box 24, Timonium, Maryland — EMMETT RUSHIN COMPANY Box 486 Roswell, Georgia — ARMSTRONG ENG. CONSULTANTS, INC., 490 Pepperidge Tree, Smoke Rise, Butler, New Jersey — ROCKFORD CONTROLS COMPANY, 549 Pennsylvania, Glen Ellyn, Ill.

ing hardware to its customer's specifications.

Five deputies, who report directly to Generals Bergquist and Terhune, are responsible for bringing USAF command and control systems from earliest concept to installed, operating hardware:

- **Advanced Planning:** Col. B. B. Townsend.
- **Technology:** Col. R. M. Wray.
- **Systems Management:** Col. N. J. McGowan.
- **Installations:** Col. D. S. Chamberlain.
- **Foreign Technology:** Col. W. R. Ray.

Also reporting directly to the ESD Commander are Major General D. C. Doubleday, commander of the Rome Air Development Center, Rome, N. Y., and Col. G. C. Willcox, head of the 3245th Air Base Wing at Hanscom Field.

In addition to a conventional military staff organization, the Electronic Systems Division currently has seven detachments.

Their locations are:

- **No. 1:** Otis AFB, Mass., to provide on-site management and support of test program on new Mark XII identification (IFF) system.
- **No. 2:** Wright-Patterson AFB, to provide liaison with Aeronautical Systems Division on joint or inter-acting programs.
- **No. 3:** Los Angeles, to provide similar liaison with Ballistic and Space Systems Divisions.
- **No. 4:** Atlantic City, to provide liaison with Federal Aviation Agency's National Aviation Facilities Experimental Center in tests of Air Force navigation and traffic control equipment.
- **No. 5:** Eglin AFB, to serve as an on-site agency for directing development testing of ESD systems, such as use of SAGE for guidance of Bomarc missiles.
- **No. 6:** Germantown, Md., to provide liaison and Air Force requirement inputs to Army ground nuclear power program.
- **No. 8:** Annapolis, Md., to provide liaison with Defense Department's newly formed Electromagnetic Compatibility Agency for which ESD has been assigned executive management responsibility.

Current Plans

The Electronic Systems Division currently has plans to add another detachment, to be located in West Germany, to serve in an on-site capacity when the Air Weapons Control System, 412-L, is installed.

One of the major efforts of the advanced planning group is aimed at increasing the credibility of ICBM warning systems. Present thinking is that it is unlikely that a decision would be

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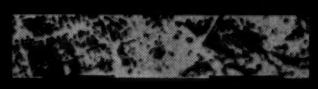
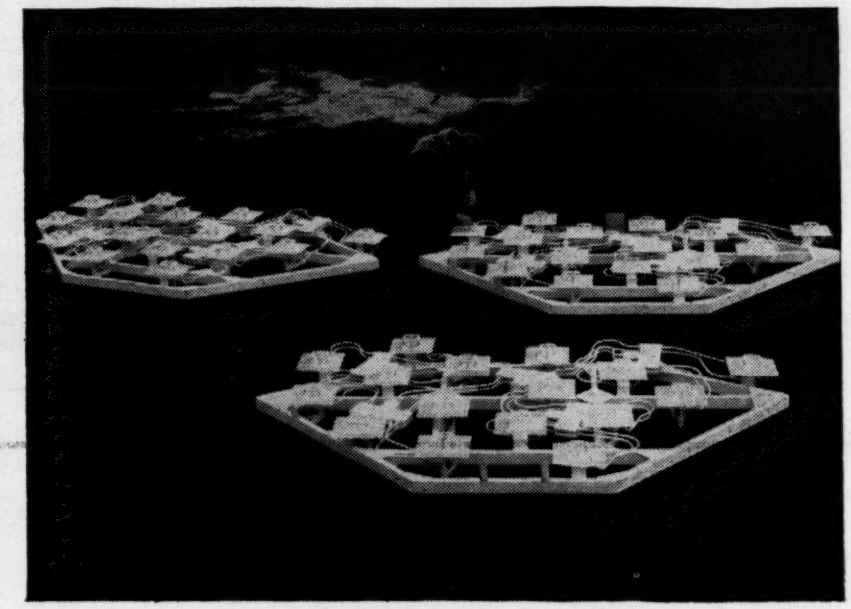
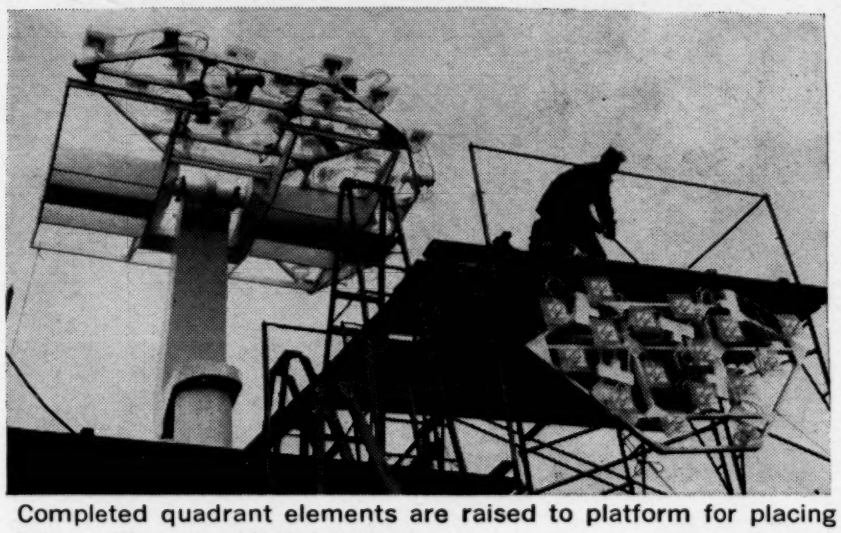
Six second access to eight million separate photographic images is possible with the Houston Fearless electronically controlled random access film storage and retrieval system, a highly creative concept of *information acquisition* and *interpretation* with precise application to all archival problems. A Houston Fearless IAI system, now being built for the United States Air Force, represents a significant contribution by the company's Westwood Division to the field of scientific/military communications and intelligence. One Houston Fearless storage and retrieval module files 10,240 high resolution photographic chips, approximately 3″ x 4″, with each chip holding as many as 850 page images plus machine readable indexing information. Any one of these eight million images is available for enlarged viewing, and print-out if desired, within six seconds. Furthermore, subsequent retrieval does not depend upon enfiling in original order. Follow-on modules provide a virtually limitless central information bank, with no appreciable increase in access time. Scientists and engineers wishing to join in this advanced photographic/electronic work, or those who wish additional information on the various IAI systems, may write to the Director of Engineering, Westwood Division, HF Houston Fearless Corporation, Los Angeles 64, California.



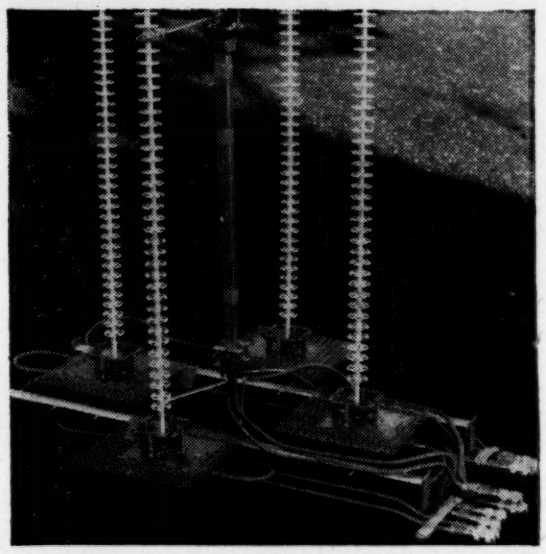
Individual unit assembly is first step in construction of antenna. Here four dipole antennas mounted on ground screen are being connected to one end of Foamflex feed lines. Special Phelps Dodge connectors are used to link the lines to the dipoles and four-way power dividers.



Completed quadrant elements, ready for placement on pedestal mount. Each quadrant is pre-assembled in exactly the same manner.



Completed quadrant elements are raised to platform for placing into position on pedestal mount.



An example of a center element unit that can be inserted into the Avien-Bogner array. This element forms a separate unit that can also be used as a portable ultra high frequency antenna.

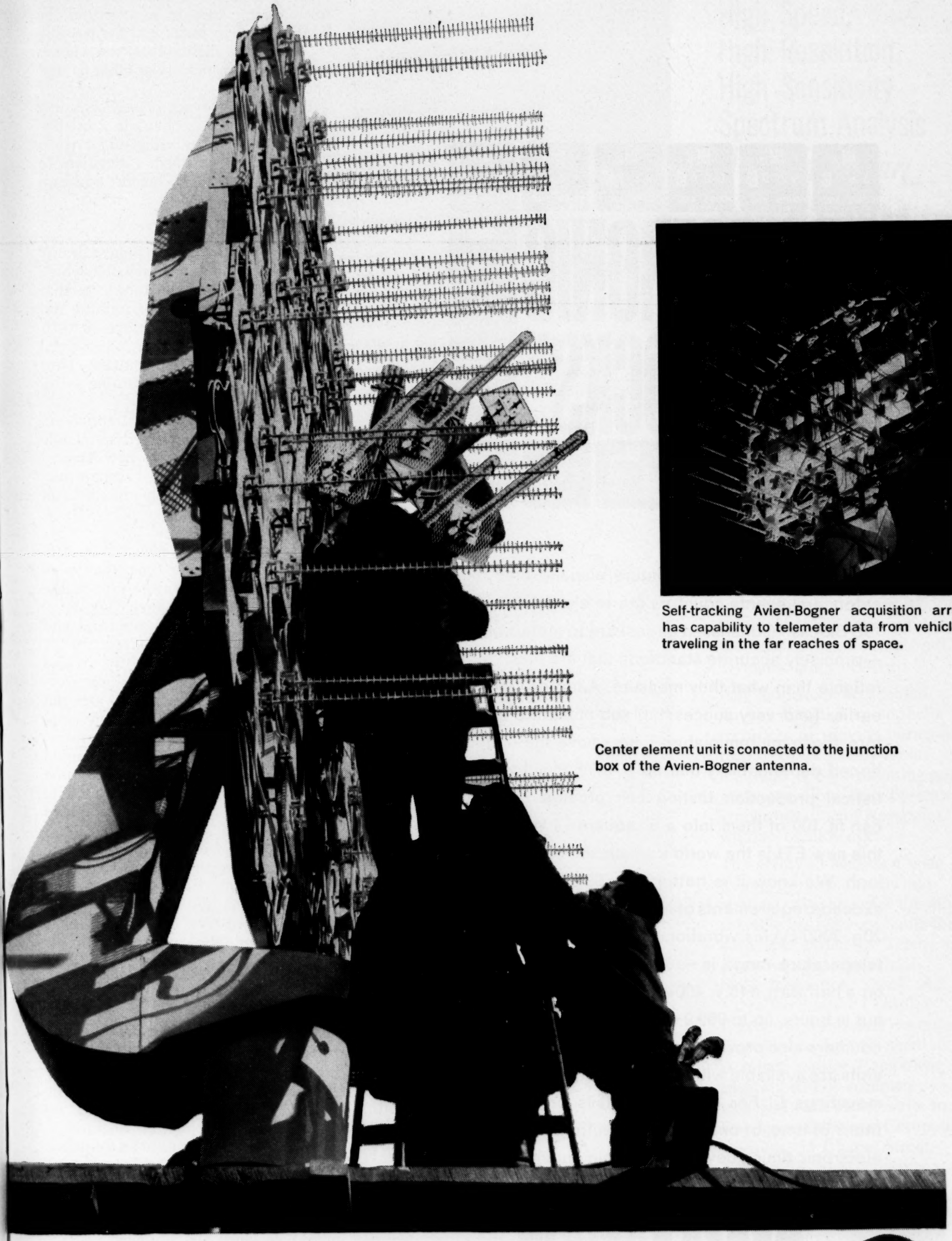
Foamflex® Coaxial Cable helps put and keep this advanced antenna system on the track!

A feed network of ⅜″, 50 ohm Foamflex coaxial cable is a critical part of the fully automatic Avien-Bogner acquisition and tracking antenna that represents an advance in the state of the antenna art. The efficient operation of this sensitive antenna is greatly increased by the low loss, high phase stability and electrical uniformity of its weatherproof Foamflex feed line assemblies. Special connectors, designed and fabricated by Phelps Dodge, link the Foamflex lines to double-tuned, strip-line, four-way power dividers in each quadrant element of the antenna.

Designed for Edwards Air Force Base, this modular array is assembled from identical quadrants, each equipped with power dividers, dipole antennas and cigar elements. In contrast to the heavier, fixed-type paraboloids, the lighter, smaller Avien-Bogner model costs less, yet has high acquisition capability for telemetry information through the use of three automatic tracking modes. Quadrant elements may easily be replaced when changes are desired in frequency bands, due to the simple design and construction of this antenna.

The feed system was planned, fabricated, calibrated and installed by A-T Electronics, New Haven, Conn. Accurate uniformity of electrical length for each cable was maintained from cable to cable within one degree at 2200 megacycles after bending.

The outstanding qualities of semi-flexible, aluminum-sheathed Foamflex have been proved in a number of applications where low loss, long operating life and a low noise to high signal level ratio are essential. If your specifications call for a coaxial cable of the highest efficiency, we recommend you investigate the capabilities of Foamflex.



Self-tracking Avien-Bogner acquisition array has capability to telemeter data from vehicles traveling in the far reaches of space.

Center element unit is connected to the junction box of the Avien-Bogner antenna.

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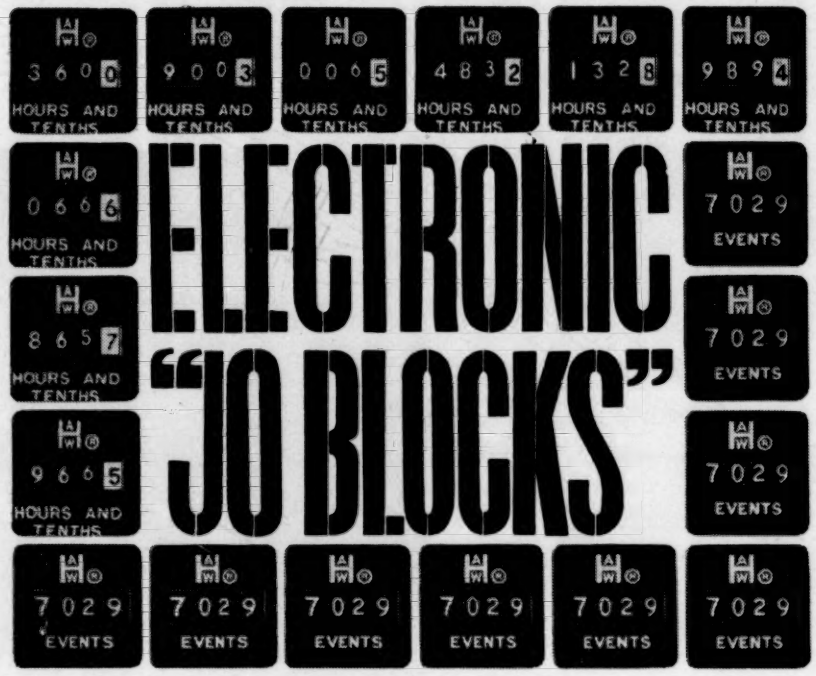

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made to launch unrecallable ICBMs solely on the basis of signals from the BMEWS radars because of the possibility, however slight, that the signals were caused by meteors or other natural phenomena.

But if other types of sensors, such as Midas satellites, become available, the credibility of warning might reach a level which justified a decision to launch our ICBMs before warheads actually hit U.S. soil.

Increased Launch

This would increase significantly the number of Minuteman missiles which could be launched. The knowledge that the U. S. had so credible a warning system and was prepared to act on such warning would itself be a powerful deterrent against an enemy attack. Thus the payoff for increased warning credibility is sizable.

Other areas receiving attention in ESD's advanced planning group include space surveillance and a new tactical control system for limited warfare use, with special emphasis on mobility and simplicity, according to Col. R. J. Lynch, assistant deputy.

Although advanced planners by definition work in future time, they work in both near and far future time scales. At the nearest end of their time spectrum, new concepts for command and control systems which appear to be within the available state of the art and needed to meet an existing or approaching operational requirement are put into the form of a preliminary development plan (PDP). This is a description of the proposed system, how it would be used, and an estimate of the time and dollars that would be required to develop and implement the proposed system.

This PDP is submitted to Air Force Headquarters as well as to the Director of Defense Research and Engineering for approval. A System Program Office may be formed even before approval is obtained and the program effort is shifted to ESD's Deputy for Systems Management.

Future Objectives

On the more distant time scale, the advanced planners develop objectives for a potential system or capability which may be of future use to the Air Force. These are called applied research planning objectives, or ARPOs. The ARPOs serve as a broad guideline to the Deputy for Technology to pinpoint the techniques which must be developed if these very advanced systems are to be feasible, and the approximate date when the advanced systems will be needed.

At present there are 19 such applied research planning objectives within AFSC, six of which are under the cog-

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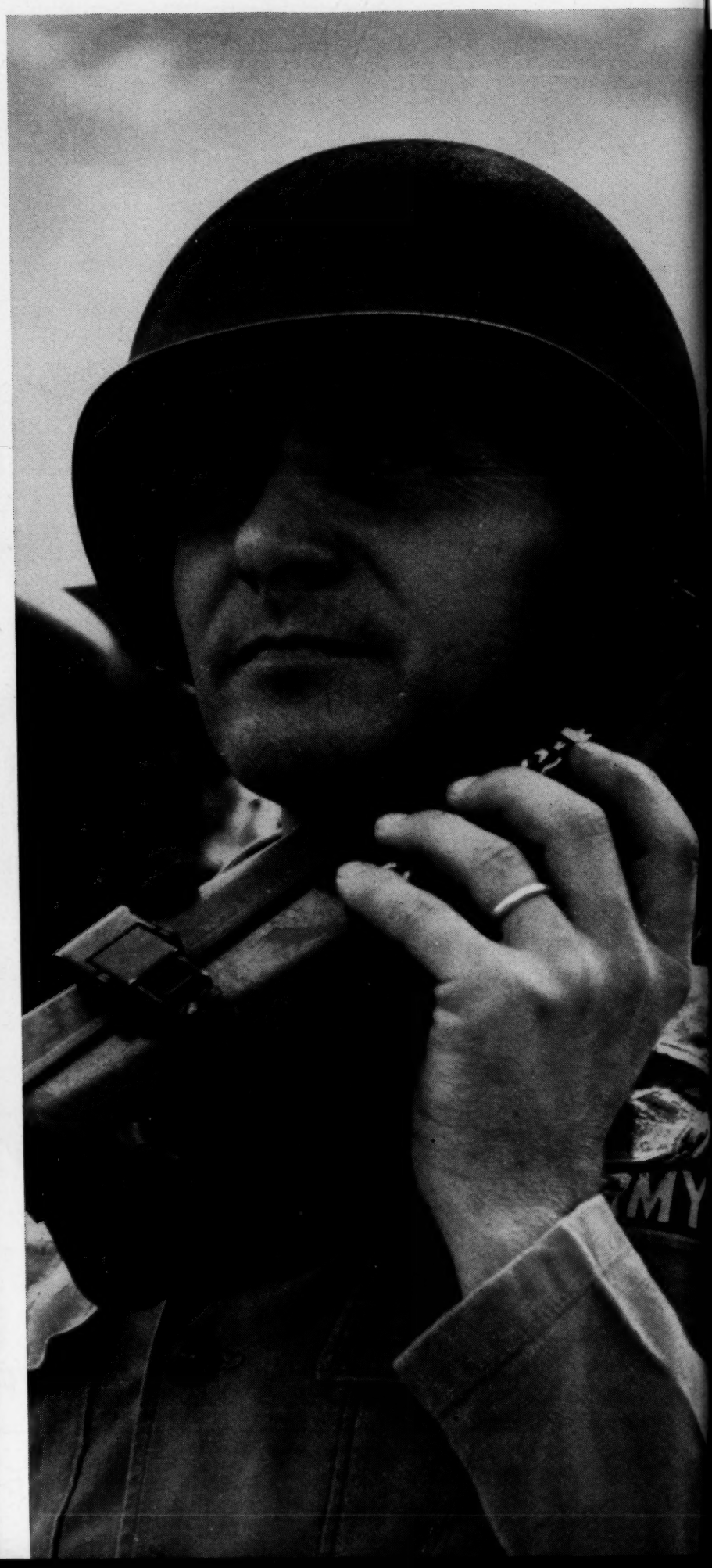

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nizance of ESD. The objectives are:

- **Intelligence Reconnaissance System.**
- **Aerospace Environmental Observing & Forecasting System.**
- **Command & Control of Defensive Forces.**
- **Command & Control of Offensive Forces.**
- **Ground-based Radiation Weapons.**
- **Geophysical Warfare.**

The Deputy for Advanced Planning has made very limited use of Study Requirements (SRs) to date, but hopes to expand their use slightly to tap industry know-how and interest in Air Force needs. Five SRs have been submitted to USAF for approval.

Advanced Planning employs about 50 people, of which about two-thirds are professional types. The bulk of these are military officers, many with technical degrees. It obtains considerable assistance and support from Mitre scientists.

"Applied research effort must relate to some future system that is required by the Air Force, but to assure that we do not overlook any important ideas, we program certain efforts without a specific application in mind," according to Col. R. W. Ballard, director of R&D under the Deputy for Technology.

The Electronic Systems Division is responsible for seven of the applied research technical program areas. These areas, and their respective Technical Area Managers (known as TAMs) are:

- **730J: Computer techniques;** Major W. E. Harris.
- **760B: Surveillance techniques;** Major Scott Sterling, Jr.
- **760C: Communications;** Lt. Col. Sidney W. Sheets.
- **760E: Electronic techniques;** Major James W. Van Horn.
- **760G: Electromagnetic vulnerability** reduction; William H. Dix.
- **760H: Intelligence techniques;** Capt. Leroy E. Ross.
- **760K: Electromagnetic wave** techniques; Capt. John J. Hobson.

The possibility of breaking out a new technical program area on ferret techniques from the 760H area now is under consideration.

For another 16 of AFSC's technical program areas in which ESD has a contributing interest, but where the TAM is assigned to another division, ESD has named technical area coordinators, known as TACs. Their mission is to keep ESD abreast of developments in these other technical areas.

Within the past year, a planning objective coordinator (POC) has been assigned to each of the possible future systems conceived by the advanced planners. These POCs work with technical area managers (TAMs) to assure that effort is under way to bring

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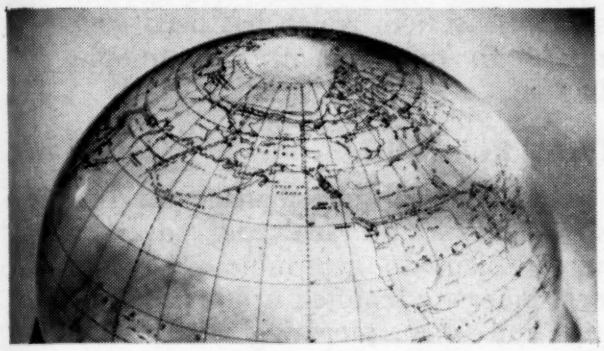

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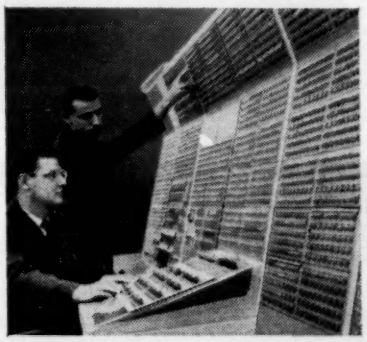

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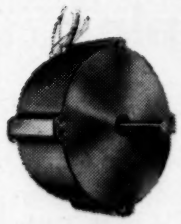

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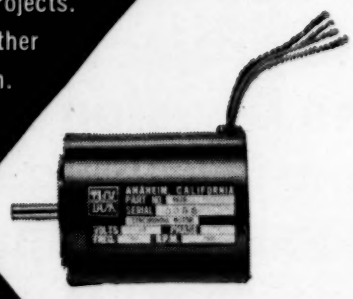

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along all of the techniques that will be required for such systems. Thus the TAM is technique-oriented while the POC is program-oriented. Expressed another way: the POC is to an advanced system what the system project officer is to an L-system which has been committed to development and to production.

TAM Role Vital

The technical area manager (TAM) is responsible for analyzing advanced system plans to determine what new techniques are required in his particular area and then preparing a technical area program for guidance of RADC, Electronics Research Directorate, Lincoln Laboratories and Aeronautical Systems Division laboratories in selecting applied research projects.

Normally the engineers and scientists at the working level facilities select and recommend specific projects, but the TAM must review and approve them before they are funded. Thus the TAM is a manager who must allocate resources and effort to bring along the techniques required for advanced systems.

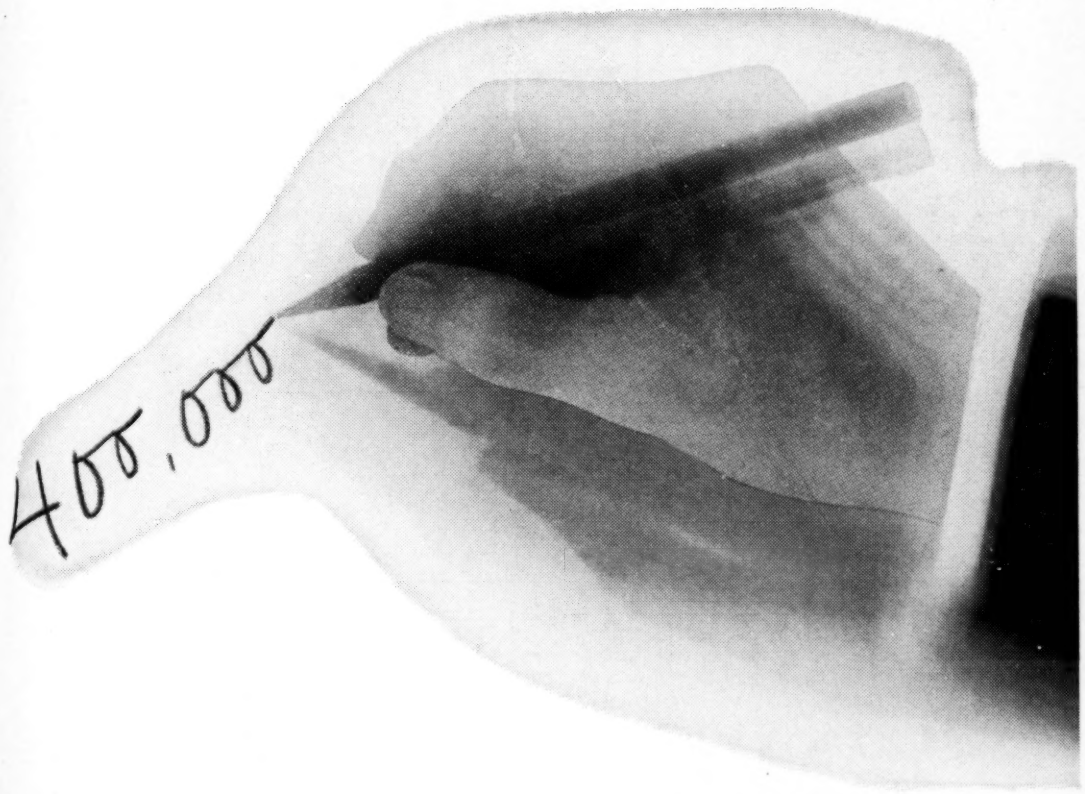
Although the TAM is available to industry contractors seeking to determine areas in which applied research is needed, ESD Headquarters encourages contractors to work directly with specialists in appropriate laboratories when seeking contracts. ESD Headquarters itself does not award such contracts directly, except for programs sponsored by the Operational Applications Laboratory.

In Fiscal 1961, the Deputy for Technology controlled approximately $107 million in funding for applied research. Of this, $40 million was handled by RADC, $7 million by Aeronautical Systems Division, $22 million by AF Cambridge Research Laboratories, $15 million went to Lincoln Laboratory and $23 million to Mitre. Present estimate of Fiscal 1962 funding, including monies from Advanced Research Projects Agency, is in excess of $100 million.

Advanced Development

In July, a new advanced development section was created under Col. R. W. Ballard, the director of Research & Development, to handle new techniques which have advanced beyond the applied research stage but which need additional evaluation before they will be ready for application to an existing L-system.

Some current examples of such programs include a new large radar and Project West Ford—an experiment to evaluate feasibility of using a belt of orbiting hair-thin metal dipoles as an artificial ionosphere for beyond-the-hori-



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Based on the fully-proved WDP-167 — fastest airborne computer in operation — the new WDP-400 occupies less than 4 cubic feet, including power supply and input /output unit. It can remember more than 7000 words, or more than 147,000 binary digits.

Its random access instruction memory is made of multi-aperture ferrite cores. Readout is non-destructive. Stored data is non-volatile, and can be altered electrically without rewiring. These unique capabilities add greatly to the system's speed, versatility and reliability.

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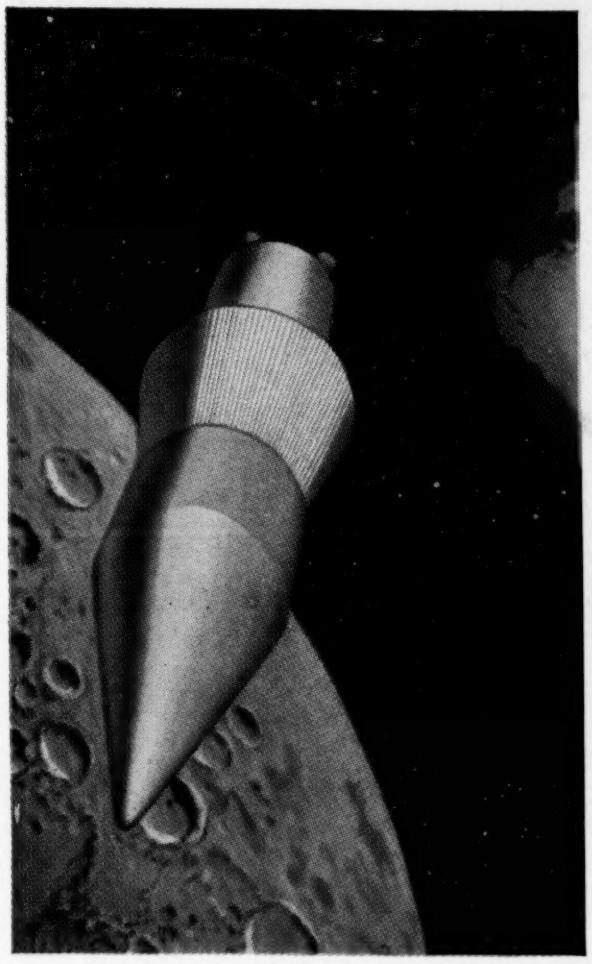
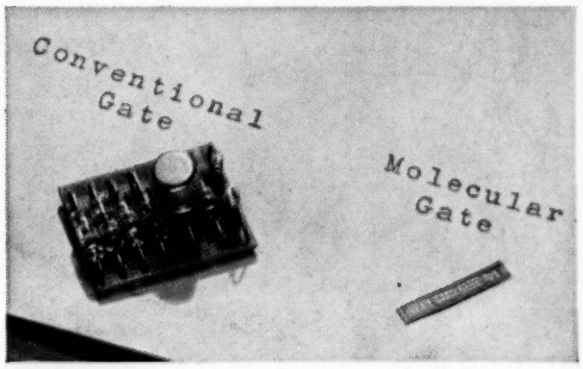


Only large scale systems or very complex problems will require the full capacity of the Westinghouse WDP-400. One such mission might be a round trip to the Moon. The system computer could handle navigation, rendezvous in Earth and Moon orbits and propulsion programming.

Years of research and use-experience have brought increased reliability, cuts in weight and volume, and improved packaging. For example, both the WDP-167 and new WDP-400 have been developed to operate at 85° C.—where many others fail.



A molecularized computer, in which single semiconductor blocks perform multiple functions, is being developed at Air Arm for missiles or satellites. It is 1/10 the size of a conventional computer. Above, right, a tiny multi-purpose gate with resistors, diodes and transistors diffused on a silicon wafer, does the same job as the larger unit.

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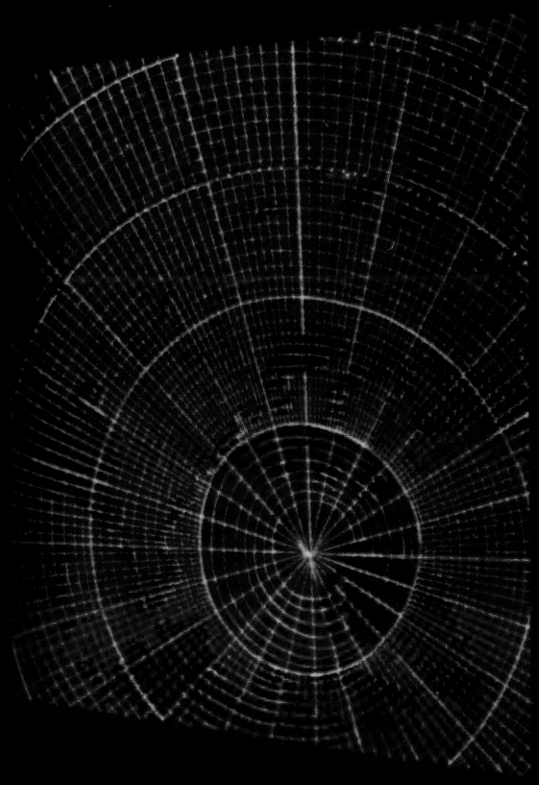
At BMEWS installations operated by USAF Air Defense Command, computers read out missile tracking data from giant radars. This information is simultaneously relayed to NORAD's Combat Operations Center.

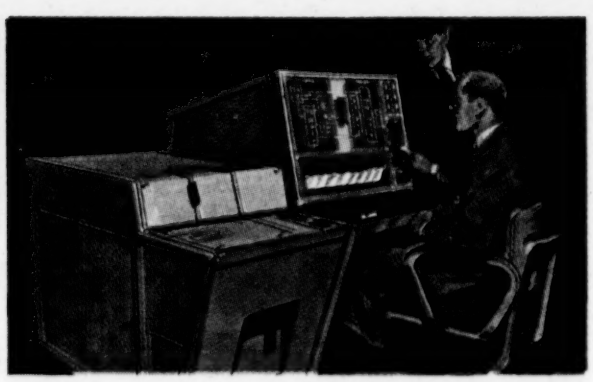
The Radio Corporation of America is prime systems contractor for BMEWS. At the COC, RCA's Display Information Processor computing equipment automatically evaluates missile sightings, launch sites and target areas. By means of data processing and projection equipment installed by RCA and a team of other electronics manufacturers, the findings are displayed on huge, two-story high map-screens in coded color symbols, providing the NORAD battle staff with an electronic panorama of the North American and Eurasian land masses.

The handling of BMEWS inputs at NORAD is an example of how RCA data processing capabilities are assuring the high degree of reliability so vital to continental defense.



At NORAD Headquarters, RCA computing equipment, the Display Information Processor (control console shown here) receives sightings data from BMEWS and processes it for automatic readout.

RCA is prime system contractor for the sprawling BMEWS three-site radar network whose probing electronic fingers reach deep into space to provide early warning of missile attacks.



RCA's Automatic Checkout & Monitoring equipment continuously tests and checks performance of portions of the system and alerts an operator when a monitored signal exceeds certain limits.

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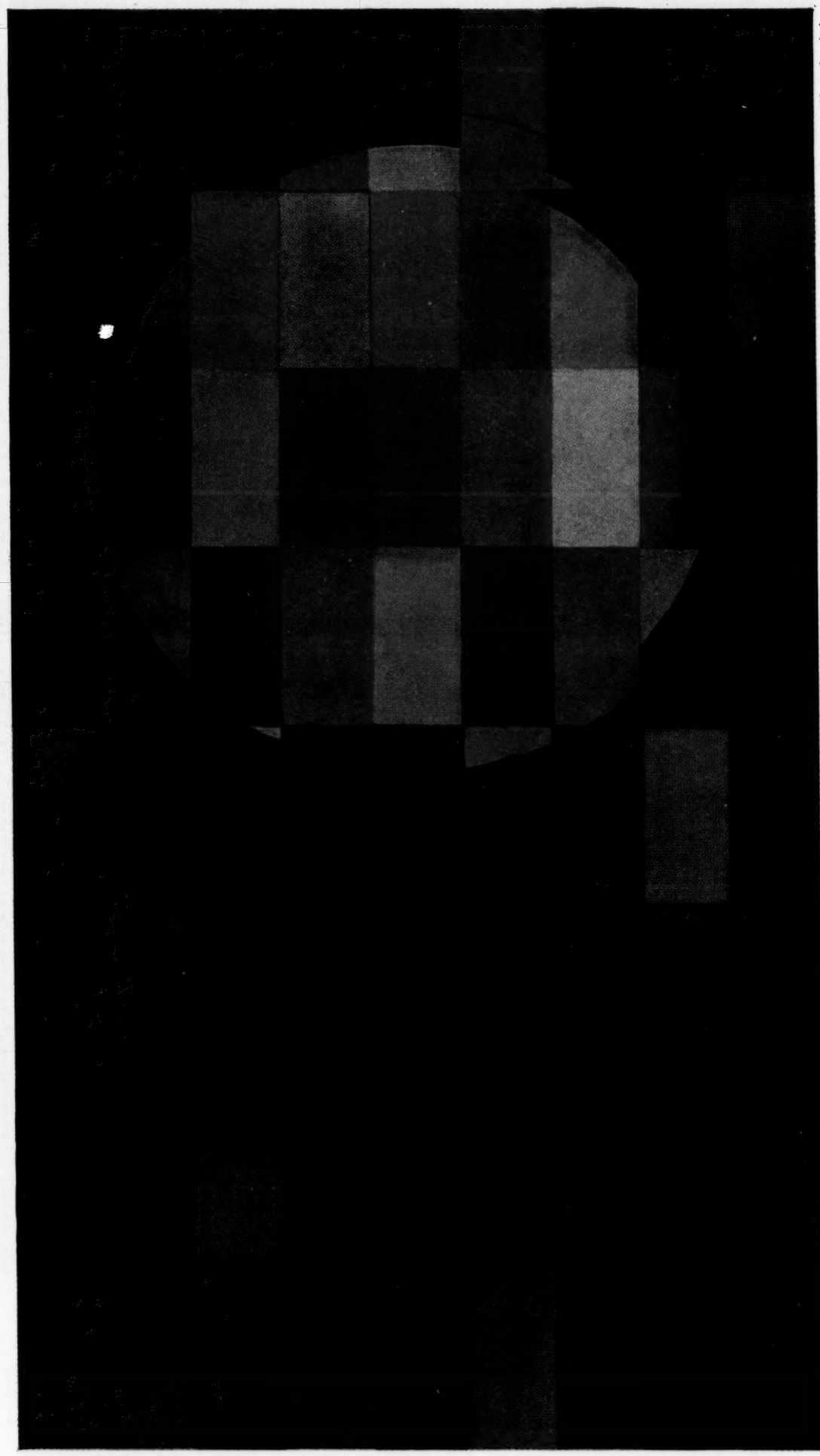

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zon communications at line-of-sight radio frequencies.

Such programs usually involve large, expensive hardware installations for testing, Col. Ballard points out. Unless they are separated from applied research, they would cause large diversions of applied research funds and manpower, producing undesirable peaks and valleys in the applied research effort.

The second major group under the Deputy for Technology is the Operational Applications Laboratory, headed by Col. W. V. Hagin. It is staffed by approximately 40 experimental research psychologists who devote the bulk of their efforts to learning more about the use of humans in command and control systems, their capabilities and their limitations.

Using a miniature command and control system built from available hardware, the laboratory is conducting simulation studies in real time on decision-making problems. The "commander" is confronted with a variety of attack threats while the psychologists watch and record his reactions, what information he uses, and how much work load he can handle without breaking down.

A related effort seeks to learn where, in the command pyramid, data filtering should take place and what kinds of people are best suited for different types of jobs in the command and control function.

There is considerable work in the area of information transfer from machines to men, and vice versa. For example, what types of symbols, displays and/or color coding are most effective for conveying information from machines to the human brain. Another investigation is evaluating the possible use of tactile stimuli produced by contact of a vibrating reed with the operator's body to obtain an additional channel for communicating with the human brain.

The laboratory recently completed an investigation to determine which of two types of logic symbols was best for use in maintenance diagrams of digital computers. One proposed set of symbols consists of identical squares with an alphabetical letter inside to indicate its function. The alternative set of symbols employed different shapes to denote the different logic functions. Laboratory investigations here indicated that the shaped symbols are preferable from a human-engineering standpoint.

Reporting directly to the Deputy for Technology, is a newly organized systems design laboratory planning office which is studying the feasibility of a facility here at ESD Headquarters to effectively simulate complex command and control systems of the future.

Despite the arsenal of computers available today, there is no existing facility with the flexibility and capacity

USAF Electronic Support Systems

System No.	Name and Mission	Status	Prime Contractor
412-L	Air Weapons Control System: Primarily for use at overseas bases to provide semi-automatic early warning and control of interceptors, missiles and offensive tactical aircraft.	First prototype system being readied for test.	General Electric
416-L	Continental Air Control & Warning System: Semi-automatic early warning and control system capable of directing interceptors and Bomarc missiles against air-breathing targets in U. S. and Canada. Heart of system is SAGE.	Partially operational	No single prime.
425-L	NORAD Combat Operations Center: Underground facility including automatic data processing-display system to assist in control of air defense forces.	Under development	Burroughs
431-L	Traffic Control & Landing Systems: Development of specialized ground and airborne systems required solely for USAF tactical missions, such as Mark XII identification, friend-or-foe.	Under development and evaluation.	No single prime.
433-L	Weather Observation & Forecasting System: Integrated, semi-automatic system for observing, processing and forecasting weather information. Joint program with Federal Aviation Agency and Weather Bureau.	Under development	United Aircraft Corp.
438-L	Intelligence Data-Handling System: Data processing system for storage and retrieval of intelligence data.	Under development	IBM
465-L	Strategic Air Command Control System: High-speed data transmission, processing and display system to provide SAC Commander with information on status of global forces and means for control of forces.	Prototype system being readied for test.	International Telephone and Telegraph Corp. (ITT)
466-L	Electromagnetic Intelligence System: Primary USAF ground-based means for collecting and processing electromagnetic intelligence. System is divided into group of equipment subsystems, each containing similar functional equipment from which necessary elements may be selected to meet any operational requirement.	Under development and test.	No single prime.
473-L	Air Force Control System: Automatic data processing and display system to provide USAF Chief of Staff with information on status of forces.	Under study by USAF and IBM	Not yet selected.
474-L	Ballistic Missile Early Warning System: System of three installations to provide early warning of ICBM attack.	Two sites operational. Third under construction.	Radio Corp. of America and Western Electric.
477-L	Nuclear Detection System (Nudets): System intended to pinpoint and indicate size of nuclear blasts within U. S.	Request for proposals sent to industry.	Prime not yet selected.
480-L	Air Communications System: Long-range program to expand capability of existing USAF global communication system to increase capacity and provide services required by other L-systems.	Under design and implementation.	ITT Communications Systems Inc.
496-L	Space Surveillance System: Expansion of capabilities of present NORAD facility to meet future requirements.	Under study and implementation.	Aeronutronic (support contract)

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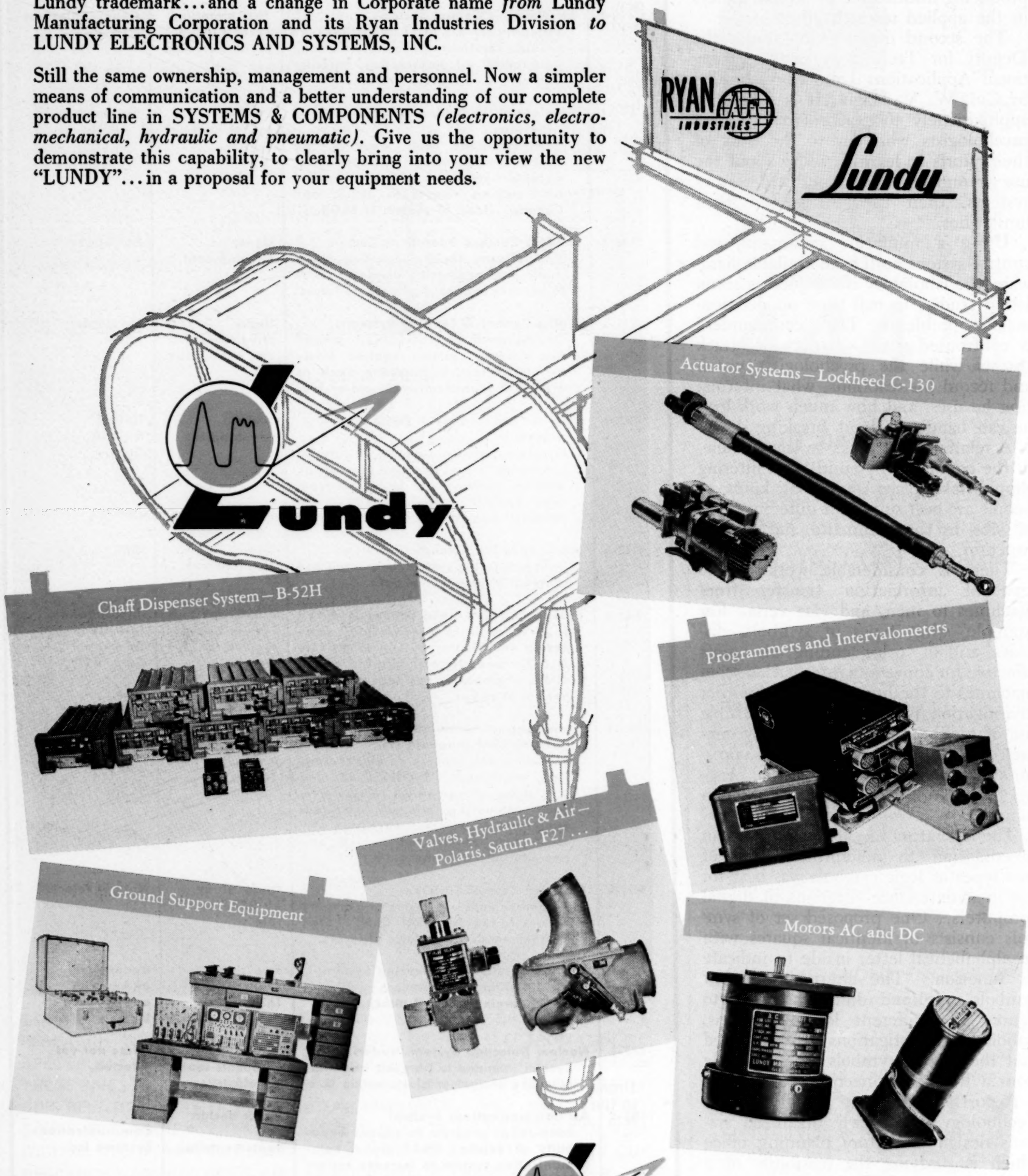

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to permit full use of simulation in the design of a complex USAF command and control system, according to ESD officials. If authorization is obtained to proceed with such a facility, it is expected to reduce development and debugging time for future command and control systems.

Systems Management

The deputy for systems management, Col. N. J. McGowan, directs the 13 System Program Offices (SPOs) which now hold responsibility for developing authorized L-systems, procuring them and placing them in operation. As of the end of Fiscal 1961 (June 30), ESD had approximately $420 million in system contracts on its books or in the process of final negotiation. Fiscal 1962 funds for continued work on existing systems and new programs are expected to total between $400 million and $600 million.

This is the largest of the five "deputates" within ESD. It has approximately 750 people, of whom about 275 are officers, most with engineering degrees. In addition there are about 300 civilians with professional-technical backgrounds.

The L-systems directed by this deputate are a diverse lot. Some, like Dew Line (413-L) represent a well-defined limited objective which, when completed, eliminates the need for continuing the SPO as a separate entity.

Other systems, such as the Air Communication System (480-L) or Electromagnetic Intelligence System (466-L) are a collection of subsystems which present a never-ending life span for improvements and expansions. The SPOs for such programs have an indefinite lifetime. At present there are 13 SPOs, the 413-L function having been merged with 480-L.

The size of the SPOs ranges from as few as two persons, for programs just getting under way or terminating, to as many as 113 in the case of BMEWS. The average number per SPO is about 30, according to Col. G. H. Duncan, assistant to the deputy for systems management.

New Office

Recenty, an office for inter-system integration has been formed to improve both the technical and functional compatibility between the individual L-systems.

The Electronic Systems Division recently has adopted PERT (Program Evaluation Review Technique). Initial use will be on a new subsystem which forms part of 480-L Air-Com Systems, to evaluate its applicability to ESD type systems.

Increased interest and participation by user commands in L-system development and design is seen as an encouraging sign by Col. Duncan. One example: SAC has sent 24 officers to participate in initial tests and to gain experience in the new SAC Control System (465-L).

A former SAC B-47 wing commander, Col. N. J. McGowan, is the new deputy for systems management. And the new SPO chief for the North American Air Defense Command (NORAD) Combat Control Center, 425-L, is Col. K. N. Retzer, who came directly from NORAD.

The deputy for foreign technology, Col. W. R. Ray, is responsible for ensuring that key managers and technicians within ESD are kept informed on significant foreign scientific and technological state-of-the-art related to ESD's areas of interest.

This group necessarily must keep itself informed of U. S. technology in the command and control field and be able to channel foreign technical data to individuals and groups concerned with such technical areas. Careful evaluation and coordination within ESD agencies of the foreign technology data is performed by the deputy for foreign technology and his group of technical analysts to ensure recognition of place-

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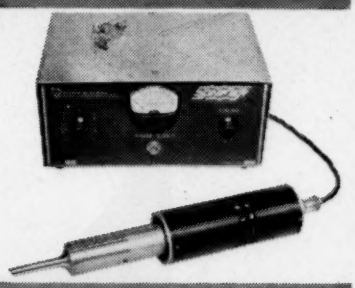

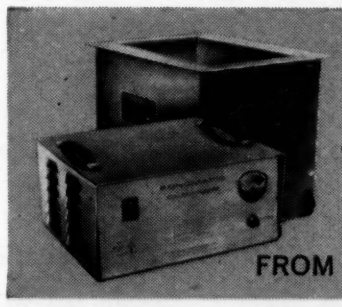

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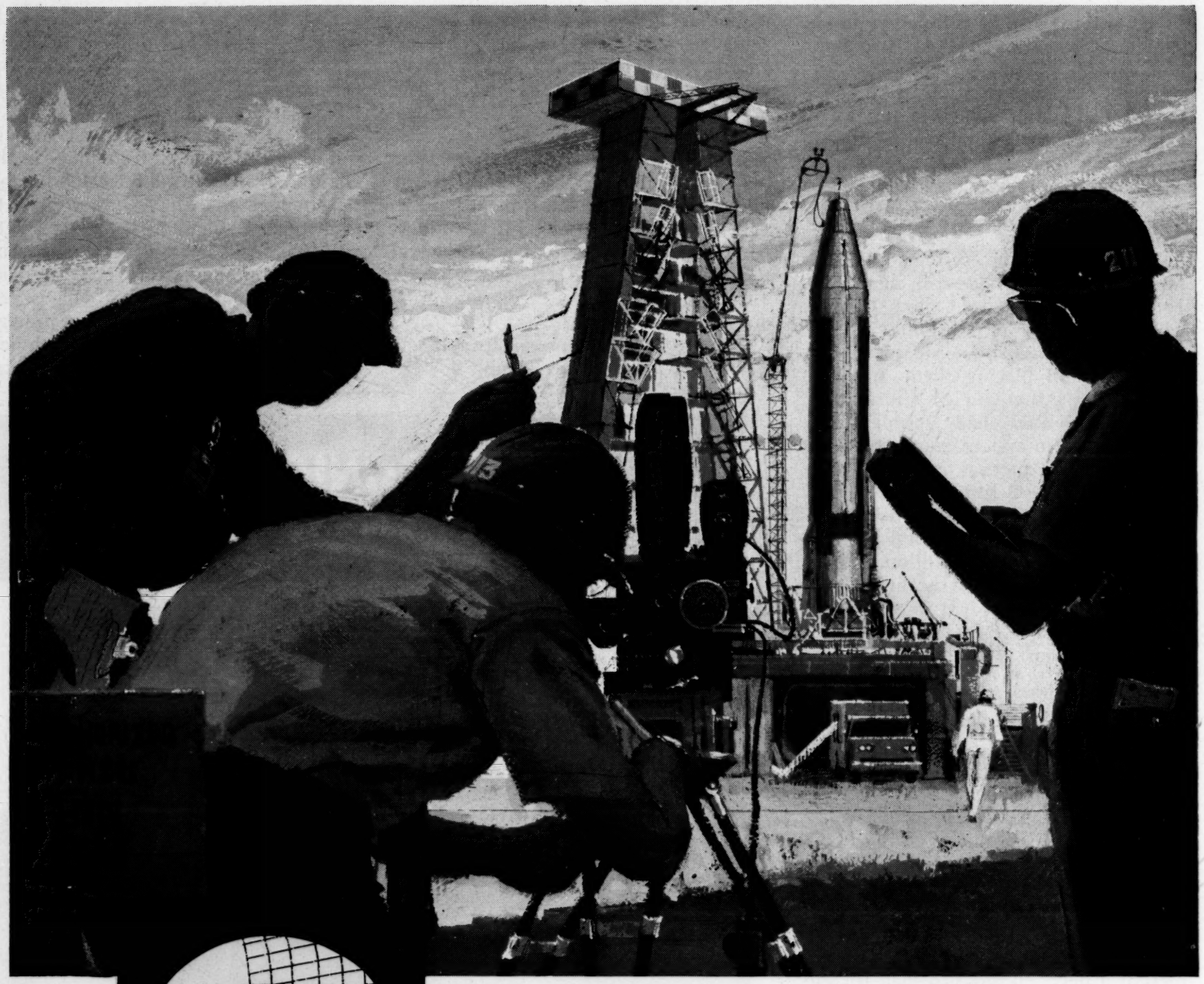

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ment of priority requirements on Electronic Systems Division research and development in response to the foreign developments.

The group serves as a focal point for establishing and evaluating requirements, collection, acquisition, translating, screening and disseminating foreign technological data, coordination and integration, policy recommendations and evaluation of state-of-the-art of foreign powers, as well as providing Electronic Systems Division close liaison with all the areas of the intelligence community.

The number of contracts awarded by ESD is small, compared to the Aeronautical Systems Division, but each contract runs into millions or tens of millions of dollars. Each SPO chief is given considerable authority in contracting, but a degree of uniformity in procurement practices must be maintained across the board within Systems Management and within Air Force Systems Command.

Staff Function

The deputy chief of staff for procurement and production, Col. R. A. Scurlock is assigned this responsibility in a staff level function. In addition to directing and managing the procurement program within ESD, it exercises surveillance of procurement policies of subordinate activities, such as RADC. Any Rome Air Development Center contract in excess of $1 million must be approved by this office before contract is awarded.

Buyers are located in some of the SPOs, but they turn to the office of the DCS/procurement and production, with its central staff of contracting officers, pricing analysts and procurement policy experts, to accomplish the contract mission.

The office is staffed with approximately 140 people, most of whom have civilian status.

This office also obtains contractor performance evaluations (Form 189 and 189A) on ESD contractors when a program is completed for use in selecting contractors for future programs, according to Lt. Col. Homer D. Day, director of procurement. Another subject of interest to this office is the amount of subcontracting which Electronic Systems Division prime contractors carry out on their programs.

Liaison Office

A Canadian production liaison office has been set up here to work closely with Canada on sharing of production. In February approximately 80 Canadian electronic manufacturers attended a conference here where they were briefed on existing and upcoming ESD programs in which the Canadian companies might possibly be able to participate.

Additionally, the visitors were instructed on how to apply for prime contracts on U. S. programs and guidance on how to apply for subcontracts with U. S. firms holding prime contracts. Present plans call for holding such a conference quarterly, according to Day.

Installations

The deputy for installations, Col. D. S. Chamberlain, has a group of approximately 50 professional civil, mechanical and electrical engineers who are responsible for translating the housing and environmental needs of new L-systems into the engineering language needed by design and construction contractors who are constructing the facilities.

Installations works closely with the deputy for systems management and its individual SPOs, to determine what kind of facilities are required, how much electric power, heating, cooling and other such needs.

At some of the more remote sites, installations must also concern itself with such support facilities as roads, water, etc.

Normally the deputy for installations does not award any construction contracts.

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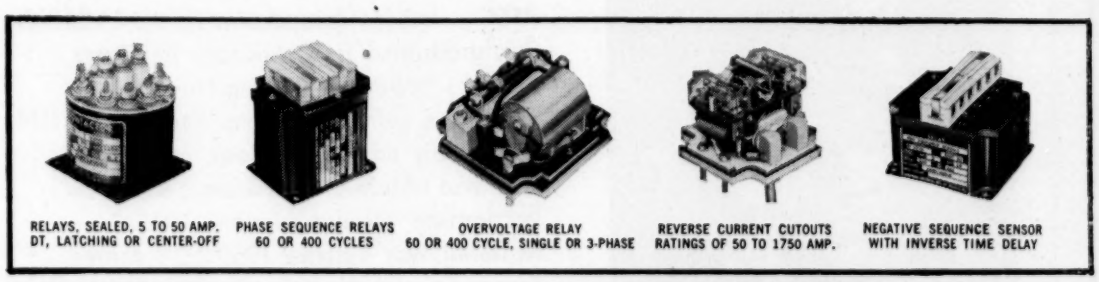

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Rome Is USAF's Engineering Backstop

RADC uses in-house and industry skills to develop capability in radar, communications and intelligence.

Rome, N. Y.—Rome Air Development Center's mission is to assure that the techniques and hardware which will serve as building blocks for future Air Force command and control systems will be available when needed, as well as providing for direct engineering support to Electronic Systems Division on systems currently under development and in use.

RADC accomplishes this by means of study, development and prototype hardware fabrication contracts to industry and applied research organizations, supplemented by in-house efforts in those areas where it is expeditious or otherwise advantageous.

During the past five years, while RADC's total personnel count has held fairly steady at approximately 1,600, the number of professional engineers and scientists employed here has more than doubled and currently runs about 700. This reflects the increased complexity of techniques and hardware employed in command and control systems today.

Some of RADC's mission responsibilities have long been assigned to the facility here, such as electronic countermeasures and intelligence data handling. Others are new and exotic, a direct result of the space age. But most of these are logical extensions of RADC's long experience in communications and high-power radar.

During Fiscal 1961, RADC had approximately $92 million available for outside contracting with an additional $15 million for its in-house effort, including salaries, travel and facilities maintenance. The $92 million for outside contracts was down about 22% from the previous year. For Fiscal 1962, funds available for outside contracts are expected to be about the same as for last year, according to Maj. Gen. Daniel C. Doubleday, RADC commander.

Although RADC is devoting increasing effort and emphasis to space defense systems, both surveillance and active defense, in recent months it has begun to examine available avionic technology for application to limited warfare situations, according to Dr. John S. Burgess, RADC's scientific director.

RADC carries responsibilities in four technical areas: data acquisition, data processing, data transmission and data display. Four organizations, known as directorates, carry out this technical mission. Each directorate is assigned "lead responsibility" in one of the four areas, but because of technical-operational overlap between the areas, no single directorate is concerned exclusively with the area for which it carries lead responsibility.

The four RADC directorates, and their missions are as follows:

- **Control and Guidance**, under Col. J. B. Bryant, holds primary responsibility for data acquisition. This encompasses applied research aimed at aerospace surveillance and control equipment and systems.
- **Intelligence and Electronic Warfare**, under Col. G. E. Branch, is responsible for data processing with principal emphasis on collecting intelligence data and the processing of all of the various types of information.
- **Communications**, under Col. Leonard N. Palmer, has lead responsibility for data transmission with techniques ranging from subterranean earth currents to spaceborne communication satellites.
- **Engineering**, under William P. Bethke, is responsible for data display and related human engineering studies, reliability studies and applied research in common component areas. Additionally it provides engineering support services to the other three directorates.

Maj. Gen. Daniel C. Doubleday, Commander, Rome Air Development Center, AFSC . . . born Johnstown, N. Y., 1905 . . . graduated U. S. Military Academy, 1929 . . . completed flying training and Air Corps communications course . . . deputy air communications officer for FEAF and observer with Atomic Bomb Investigation Mission, Japan, 1945 . . . National War College 1950 . . . Armed Forces Special Weapons Project, Sandia Base, N. M. . . . command of Rome Air Development Center and then to Airway and Air Communications Service, 1954 . . . assumed command of AACS 1958 . . . holds the Distinguished Flying Cross, Legion of Merit and Order of the British Empire.

Control & Guidance

The Control and Guidance Directorate consists of three major laboratories:

- **Space Defense Systems,** under Lt. Col. J. F. Strother.
- **Control Systems,** under Joseph M. Eannarino.
- **Techniques,** under Arthur J. Frohlich.

There are approximately 230 people in the directorate, about 40% of them in the Control Systems Laboratory and the balance divided between the other two laboratories.

The prospect of space becoming an arena for military operations has created challenging new problems for radar in its traditional role of surveillance and also has focused attention on its possible application as an active weapon for defense against space vehicles.

With the advent of the ballistic missile threat, designers had to push the range of surveillance/tracking radars from several hundred miles against large airplane targets out to several thousand miles against small nose cones.

Now designers must take another giant step to expand radar range out to tens of thousands of miles for space surveillance. This poses problems beyond merely developing higher power transmitters and more sensitive receivers.

For example, because the beam width of a conventional radar antenna increases directly with range, its ability to resolve small targets at longer ranges is degraded proportionately. Any effort to obtain better resolution by increasing antenna size runs into serious mechanical-structural problems.

At ranges required for deep space surveillance, the transit time required for each radar pulse to reach the target and return slows down the rate at which a given volume of space can be scanned. Yet to increase the probability of target detection, it is desirable to maximize the number of "looks" at the target in a given time interval.

These problems illustrate why RADC is placing considerable emphasis on new

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QKN-884	AuGe	Silicon	#2	1-9 microns
QKN-1004	AuGe	BaF2	#2	1-9 microns
QKN-961	CdGe	BaF2	#3	1-17 microns
QKN-902	CuGe	BaF2	#4	1-17 microns
QKN-1007	CdGe	KRS-5	#3	1-25 microns
QKN-1008	CdGe	KRS-5	#4	1-25 microns
QKN-1009	CuGe	KRS-5	#4	1-30 microns
IR Polarizer		98% polarization		4 microns & beyond

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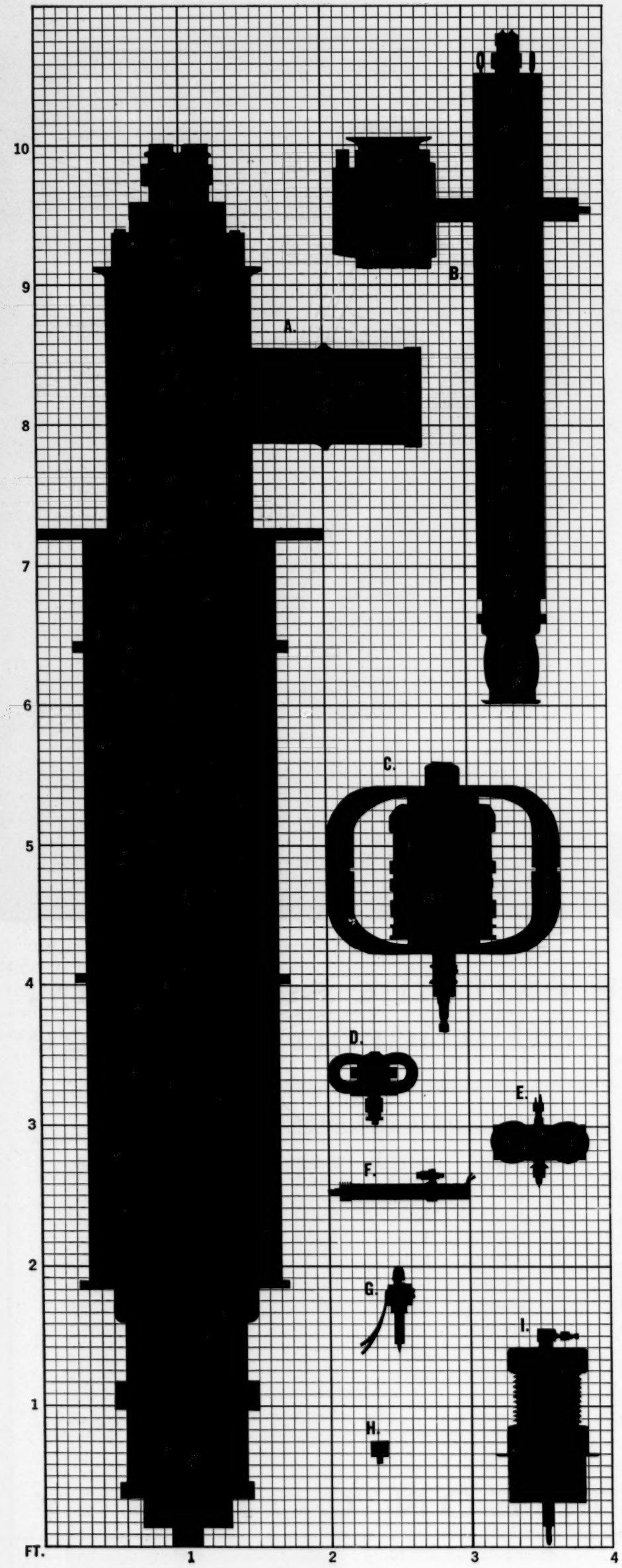

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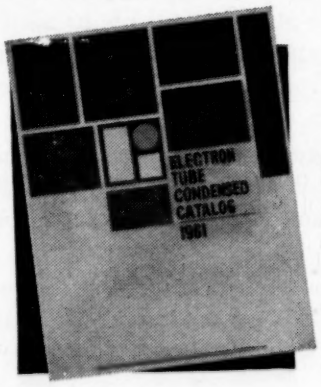

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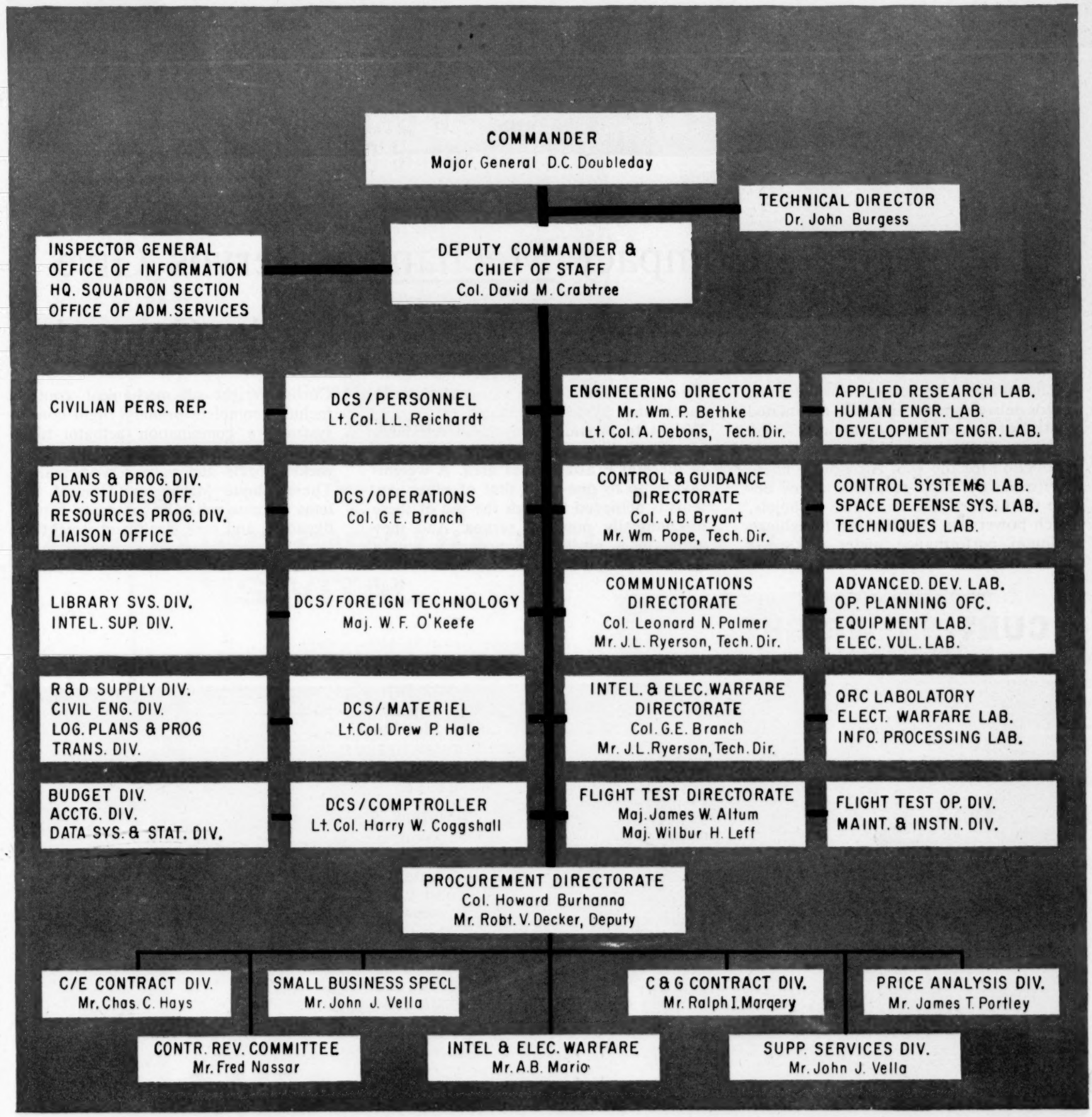

ROME AIR DEVELOPMENT CENTER ORGANIZATION

radar and antenna techniques. One example is the electronically steerable array radar (ESAR) now under test by Bendix Radio. Initial RADC sponsored work on electronically steerable array antennas began five years ago. Recent work has ARPA support.

The Bendix ESAR, measuring approximately 50 x 50 ft. and resembling a drive-in theatre movie screen inclined at an angle to the horizontal, contains 6,400 individual antenna elements. In a fully operational version, each antenna element would have its own transmitter and receiver, but the current prototype employs only 760 active elements. By controlling the phase of radiation from each antenna element, a beam of almost any desired shape can be produced, and caused to scan at extremely high speeds. Beam can move from any point in the antenna's area of coverage to any other in 20 microseconds.

Using a digital computer to select and control the antenna's transmitting and receiving elements, the antenna can simultaneously scan and track multiple targets on a time-sharing basis.

In addition to these important advantages, the fact that each of the hundreds of antenna elements employs its own transmitter makes it possible to develop extremely high effective powers using hundreds of moderate power transmitters. Other expected advantages include extremely high target-handling capacity, high data rates and the increased ease of hardening the structure.

Work to date in electronically steerable arrays has been directed by the Techniques Laboratory.

A new type radar, conceived by RADC scientists, shows promise of providing 100:1 improvement over existing equipment in measuring the angular position, range and velocity of targets in deep space and currently is under investigation by the Space Defense Systems Laboratory.

Known as Active Swept Frequency Interferometer Radar, or ASFIR for

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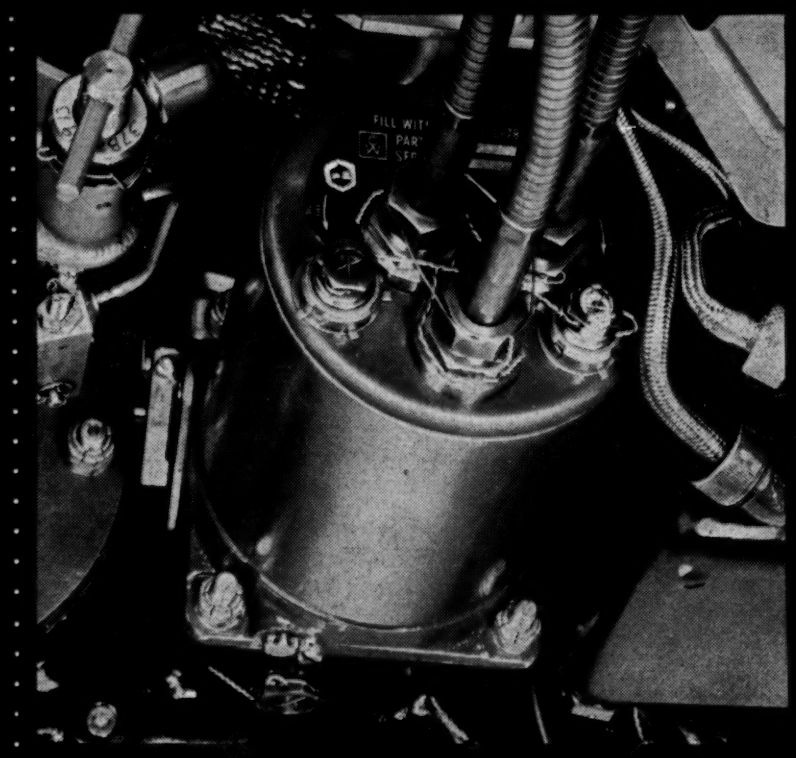

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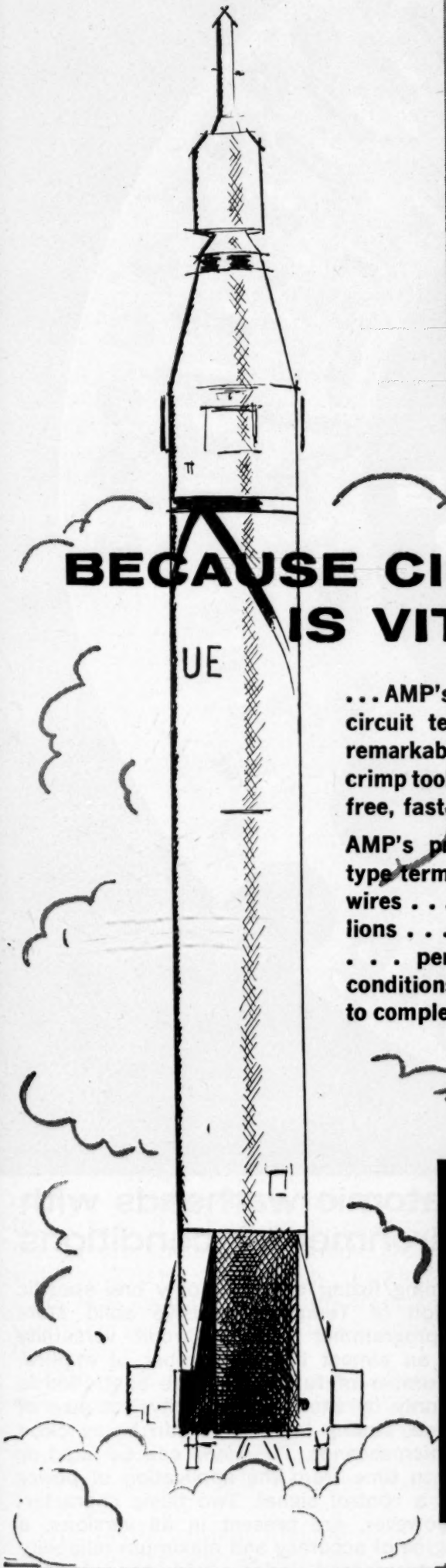

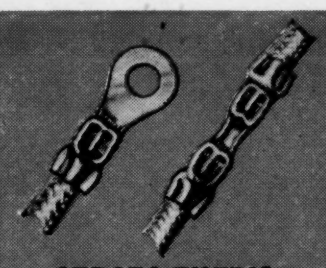

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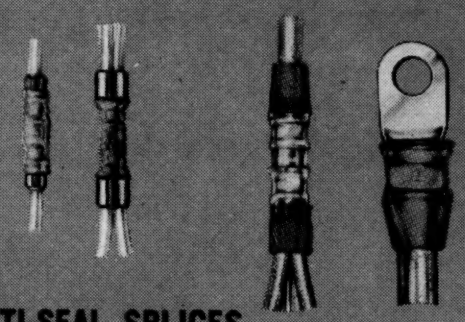

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- exceed millivolt-drop specifications
- finest nylon pre-insulation
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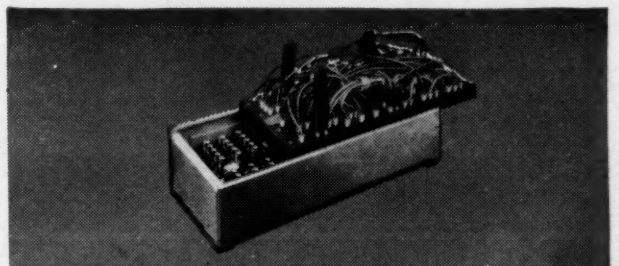

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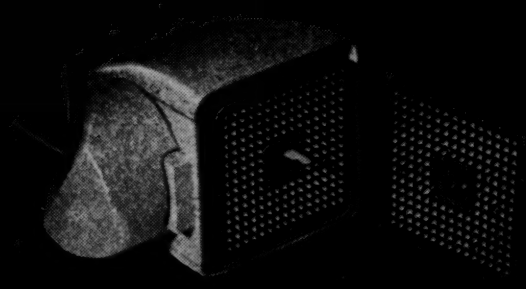

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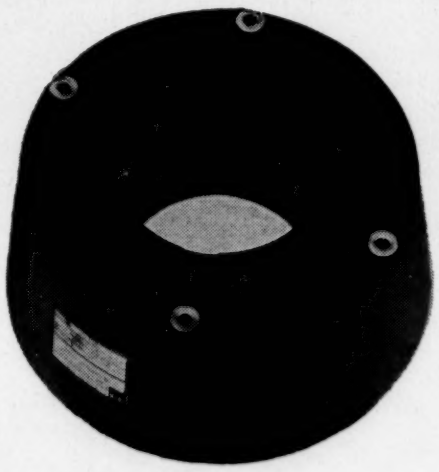
DEVELOPMENT SPONSORED BY PICATINNY ARSENAL

All-electronic digital timing programmer controls atomic warheads with better than 0.1% accuracy under extreme environmental conditions

Developed in cooperation with the U. S. Army Tactical Atomic Warhead Laboratory at Picatinny Arsenal under a program of supporting research, this new digital timing programmer represents a significant advance in the state-of-the-art for arming/fuzing devices. For this particular application, the programmer includes two identical channels, each with a 4-stage, adjustable timing program *accurate to within 0.1%* under any combination of temperature (−65°F to +165°F), voltage (26.5 ±5.5 Vdc), vibration (50 g's/2000 cps), shock and acceleration (100 g's). This new standard of accuracy under rugged environmental conditions is, however, practically meaningless until it is combined with another, equally important consideration always present in modern atomic weapon systems — *reliability*. The programmer's proven solid state design, *without any moving parts*, together with the unique packaging methods utilized, potentially offers a safety-reliability level substantially higher than previously attainable.



This arming/fuzing device is only one specific application of Tempo's exclusive solid state digital programmer design. Circuit versatility permits an almost infinite number of applications. Number of functions to be controlled is limited only by the allowable physical size of the device. Timing increments can be as close as 10 microseconds. Functions can be fixed or variable in time from the application of power or from a control signal. Two basic characteristics, however, are present in all versions; a high degree of accuracy and maximum reliability — both guaranteed under a wide range of extreme environmental conditions. If these characteristics are vital requirements of *your* timing programmer, Tempo can help you.

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short, the new concept would combine the techniques of more conventional pulse-compression radar with those of interferometry. This is the technique of measuring the relative phase (transit time) or the rate-of-change of phase of signals from a target at four (or more) separate, physically displaced antennas. The General Electric Mistram missile tracking system planned for the Atlantic Missile Range, and the earlier GE radio command guidance for the Atlas, are representative of a system using conventional interferometry techniques.

As in a conventional interferometry system, receiving antennas would be located at the four ends of a cross. The transmitter would transmit first a sequence of pulses in which the carrier frequency is modulated with an FM ramp function followed by a sequence of pulses of constant frequency with no modulation, after which the cycle would be repeated.

Instead of measuring the time difference between receipt of the target echo at each pair of stations, to determine target angular position, ASFIR would measure the instantaneous difference in frequency of the FM ramp modulation as received at each pair of stations, which provides equivalent information and which can be measured more precisely, according to scientists at RADC.

This ramp modulation frequency difference in combination with the time delay between transmission and receipt of the pulse, can be used to determine target range. Rate of change of target angular position and of target range can be obtained from similar frequency difference measurements of the target echos received from the unmodulated (CW) carrier pulses.

The inherent precision of ASFIR is expected to permit measurement of velocity of propagation and the atmospheric refraction index. It avoids the need for a precise timing reference between pairs of stations on an extended baseline and the need for extreme phase stability, RADC scientists say. Furthermore, it is expected to be able to make maximum use of existing state-of-the-art hardware.

The Space Defense Systems Laboratory expects to procure components for a demonstration of feasibility installation during the coming year, with the hope of starting field tests in Fiscal 1963.

One of the current in-house investigations under way in the Space Defense Systems Laboratory is to determine how much microwave power concentration is required to produce ionization of the atmosphere at different altitudes. With new higher power radars producing an extreme concentration of radio frequency energy, there is the growing possibility of producing man-made ionization which might obscure a target which the radar is attempting to detect.

There also has been speculation that such man-made ionization could be used as a defense against ballistic missiles and space vehicles. Both Soviet and U. S. scientists are known to be considering the use of high intensity microwave beams to produce "artificial lightning balls."

Using an ellipsoid reflector to concentrate microwave energy and focus it on a vacuum chamber, RADC scientists have achieved power densities of 10,000 watts per square centimeter, producing an ionization discharge. In later experiments, it is planned to introduce different impurity gases into the vacuum chamber to determine their effect on ionization.

Another program within the Space Defense Systems Laboratory has been a study of the feasibility of a sextile libration point surveillance system, consisting of satellites equipped with suitable sensors. The sextile points are two of five possible locations where the gravitational attraction of the earth and the moon theoretically should balance the centrifugal forces due to rotation of the earth-moon system. The two sextile points are so named because

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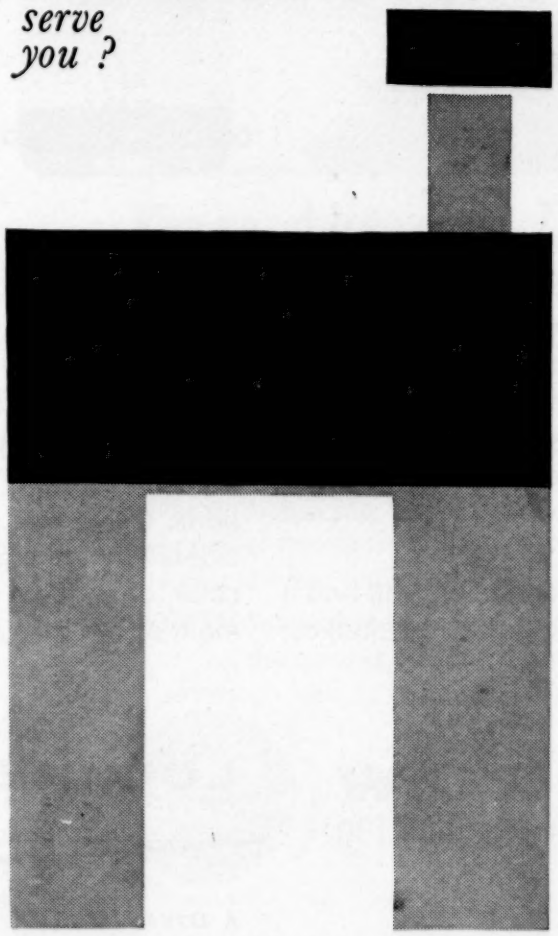

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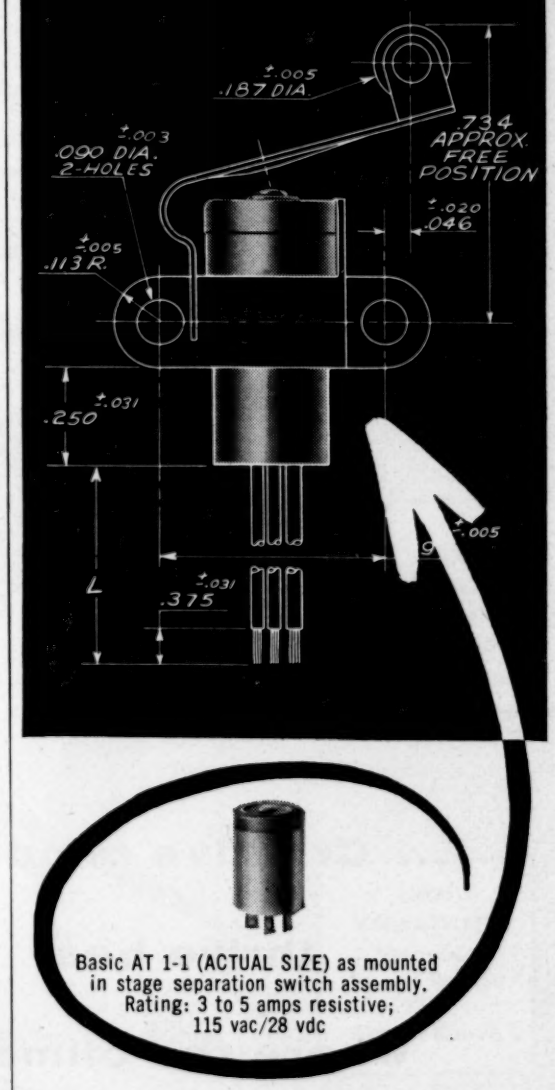

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The smallest, HERMETICALLY SEALED, precision-calibrated, snap-acting switch ever designed is the nucleus of custom-designs like the missile stage separation switch assembly shown. Other KLIXON switch packages have been specified for guidance, ground support, firing circuits, communication equipment and similar critical functions . . . in the Polaris, Pershing, Minuteman, Redstone, Discoverer, Samos, Midas and Centaur Missiles . . . where reliability is prime requisite!

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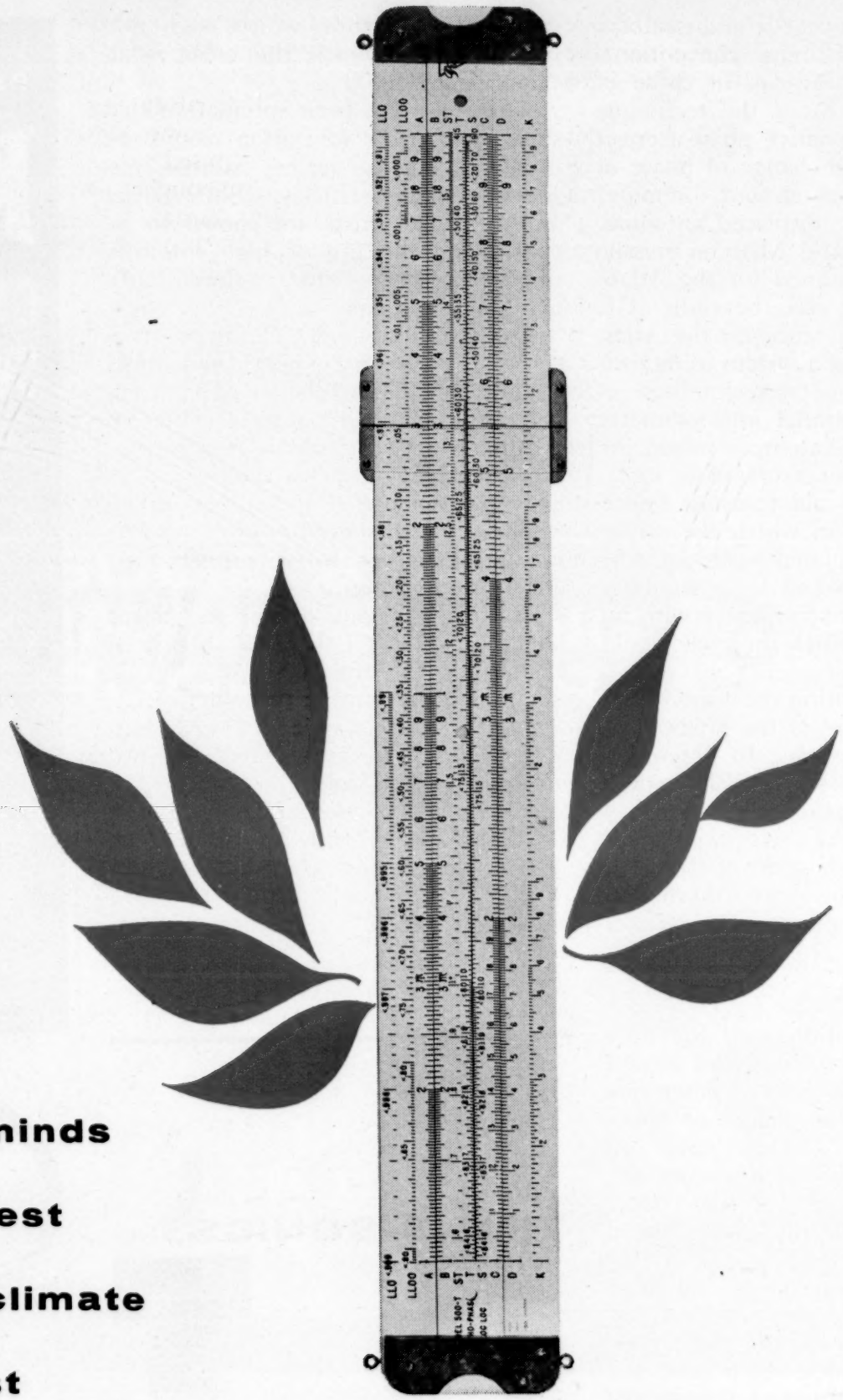

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they are located on the lunar orbit, one approximately 60 deg. ahead and the other approximately 60 deg. behind the moon.

If satellites could be placed in orbit into these sextile libration points, natural forces would tend to keep them in this position with little expenditure of energy by the vehicle for station-keeping.

The Techniques Laboratory of the Control and Guidance Directorate is responsible for sponsoring and conducting investigations into fundamentally new technical approaches and components for application to radar and other data acquisition functions. Approximately 70% of its programs are conducted by outside contractors, with the remaining 30% being carried on in-house.

Typical Programs

Typical of the types of investigations and programs under way at present by the Techniques Laboratory are the following:

- **Plasma switch,** developed by RADC and Brooklyn Polytechnic Institute scientists as a possible replacement for hydrogen thyratron tubes in extremely high-power radar, provides extremely fast switching and is expected to have long life because it uses no electrodes. An experimental plasma switch has been built by RADC and operated at 20,000 volts with repetition rates of 120 per second.
- **Variable polarizer,** capable of instantly changing the polarization of a radar signal to any linear angle, or varying polarization from circular to elliptical, is now under test here. Such a device can be used to give each pulse a discrete polarization identity.
- **Dispersive filters,** for use in radars employing pulse compression techniques.
- **Electron traps,** which might be used instead of TR tubes, are under study. Such a device could become conductive by quickly pumping in electrons after which the electrons could be quickly quenched to make the device non-conducting.
- **Phased arrays,** similar to those used in Bendix ESAR radar, are under intensive investigation. Particular emphasis is on the problems of increased coverage, broad banding, hardening, reduction of the total number of elements required and beam control and programing.
- **Luxemburg effect,** in which modulated waves from one radio transmitter react with the carrier wave from another station of different frequency in the ionosphere, causing the signal from the former to be audible to receivers tuned to the latter, is under laboratory investigation. RADC scientists are attempting to reproduce the effect in the laboratory to prove out theories on the basic mechanism responsible for the phenomenon.

The Techniques Laboratory also operates a high-power microwave test facility at RADC which is used to evaluate new microwave components developed by RADC and industry. The facility can generate peak powers of 10 megawatts at L-band and S-band. With the use of available ring resonators, peak powers of 40 megawatts can be produced at L-band and 25 megawatts at S-band.

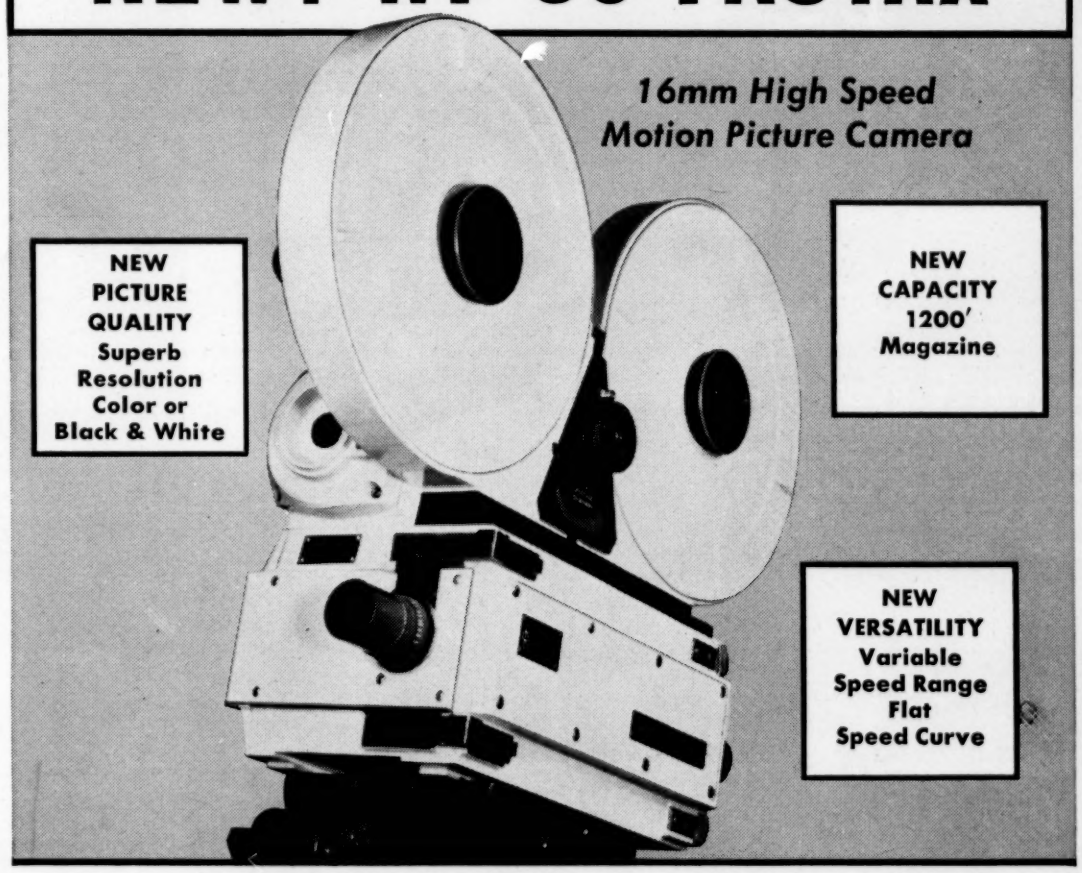
Currently under construction is a new X-band source, scheduled for completion late this year, which can generate 10 kilowatts average power continuous-wave. By early next year, a five-megawatt peak power C-band source will be available.

Control Systems Laboratory

The third of the three groups in this directorate is the Control Systems Laboratory which is assigned technical responsibility for two of the USAF's L-system programs under the management direction of System Program Offices at Hanscom Field:

- **Air Weapons Control System** (412-L), an air defense system designed for

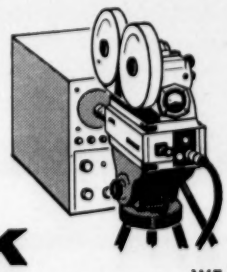
NEW! WF-30 FASTAX



Years Ahead in Design and Performance

A high speed camera with large film capacity . . . with a variety of speed ranges and high resolution has long been wanted by industry, the military and the government. The FASTAX WF-30 fills all these requirements and more. Darkroom loaded, "T" core, the magazine holds sufficient film for most studies. Camera versatility is another key feature. Variable speed range, controlled by a solid state loop servo device . . . rapid acceleration with flat speed curve within ±4% selected rate . . . start-stop capabilities. Superb resolution over entire frame results from excellent lens system and a sector shutter between rotating prism and focal plane.

WRITE for complete information and prices on WF-30 . . . the newest FASTAX in the wide line of Wollensak high speed motion picture cameras.



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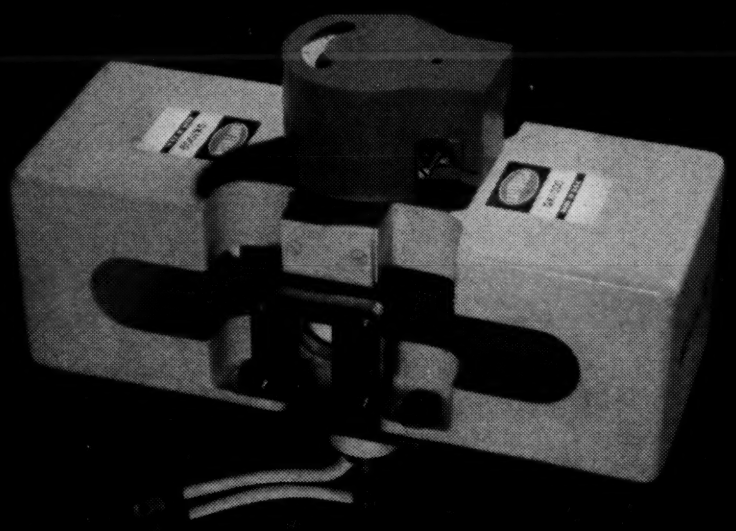
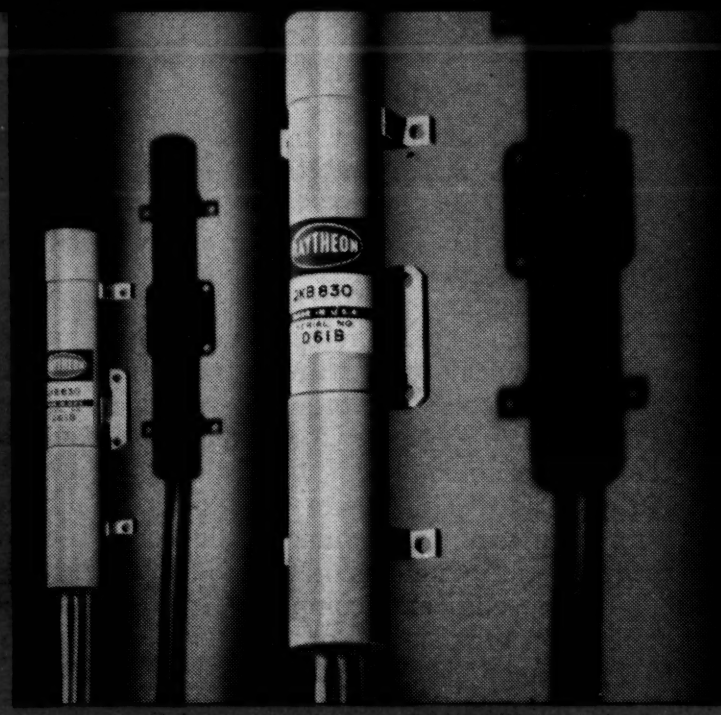


ALL CERAMIC AND METAL X-BAND MAGNETRON provides 250 kW power at 8,500-9,600 Mc. Available in mechanically and hydraulically tuned models, QKH 1000 and QKH 1001.



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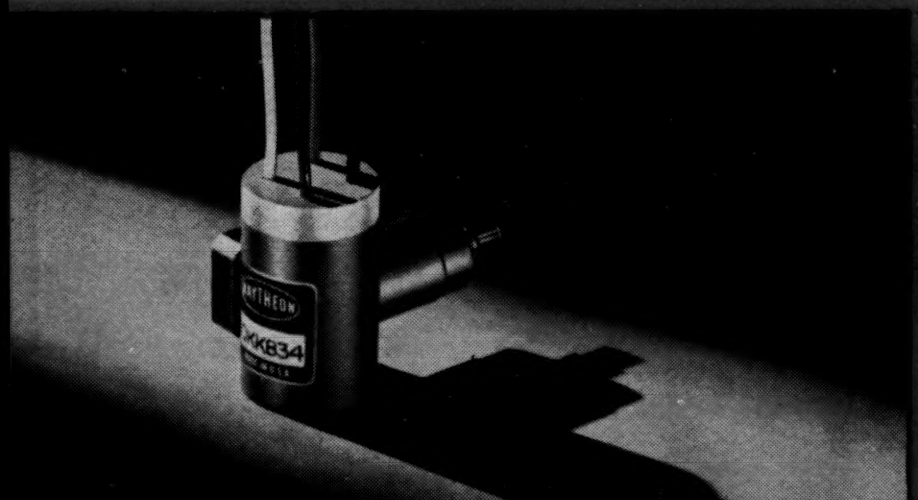
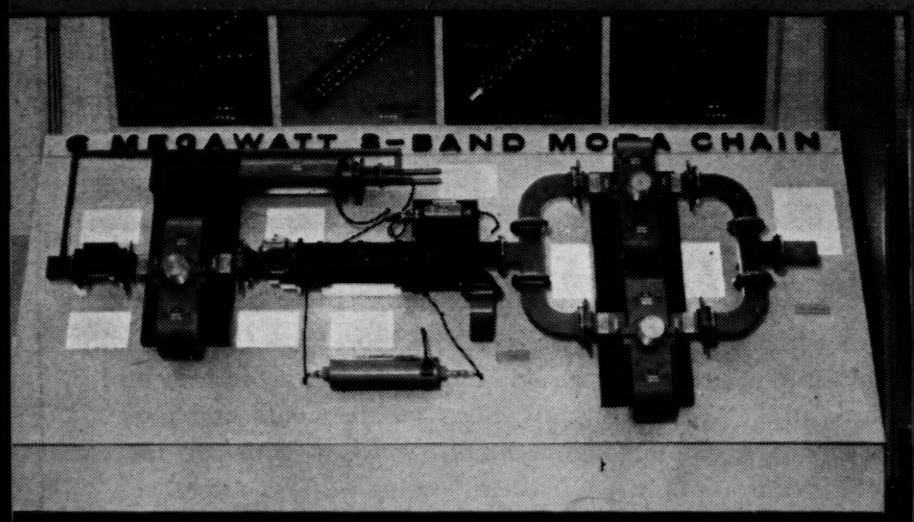


EXTREMELY RUGGED K-BAND KLYSTRONS have very low microphonics, excellent thermal stability. QKK 923 for 23.5-24.5 and QKK 834 for 34.0-35.6 kMc.

NEWEST ELECTRONICALLY TUNED BWO's have 40 mW minimum power output; are half the size and weight of their predecessors. QKB 890 for 12.4-18 and QKB 891 for 18-26.5 kMc.



PHASE STABILITY AND HIGH EFFICIENCY are features of Raytheon designed high-power amplifier chains for sophisticated search and track radar applications. Chain shown is one example of Raytheon's ability to supply microwave tubes, ferrite devices and magnetic components in a completely integrated package.

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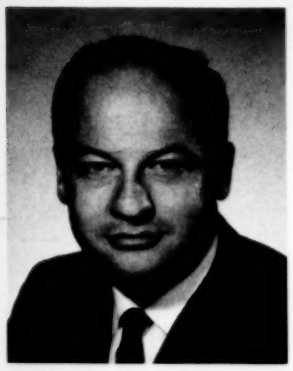

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Requires engineers at various levels of experience including senior men capable of taking over-all project responsibility in the synthesis and analysis of control systems.

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Experience in hypersonic gas dynamics, heat transfer, ablation, re-entry vehicle design and shock layer ionization will be most useful.

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Orbital Mechanics Analysts

Trajectory analysis and solution of problems involving conic and perturbation techniques.

Space Power Engineers

Openings include development of electronic propulsion systems for space probes. Positions call for capability of working in either a project or research capacity on direct energy conversion and storage systems. Openings exist for both junior and senior engineers. An advanced degree in Electronics or Physics is preferred.

Armament Control Analysts

Experience in the synthesis of integrated fire control loops including the tie-in of sensing and guidance equipment is desirable. A strong background in target data sensing devices, particularly at optical wavelengths, is very helpful, as is experience with computers.

Instrumentation Engineers

Involves the integration of advanced instruments into spacecraft such as Surveyor. Includes design for in-flight reliability; technical direction of instrument subcontractors; development of test programs and test equipment; and determining instrument interactions. Experience with subcontract procedures is also helpful.

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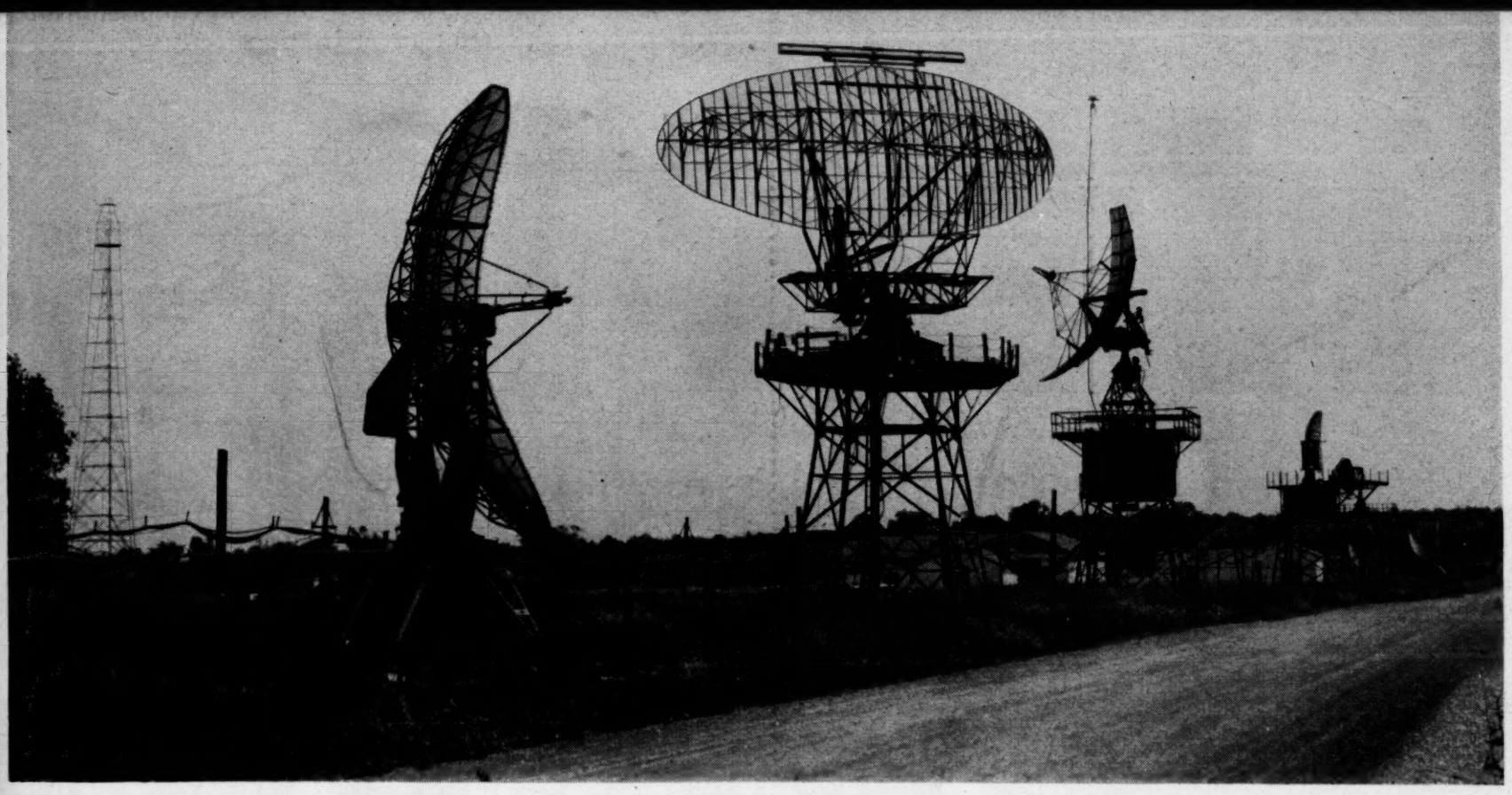

ROME AIR DEVELOPMENT CENTER'S test facility at nearby Verona, N.Y., mounts a variety of radars.

use at overseas bases, sometimes referred to as a "little SAGE."

• **USAF Headquarters Control System** (473-L), designed to enable top Air Force officers to control logistic and support forces from a central command post in the Pentagon.

The development of the 412-L weapon control system began here at RADC several years before the centralization of system management at Hanscom Field under ESD and its predecessor organization. It is intended to provide semi-automatic surveillance and control of friendly aircraft in the airspace around an overseas base.

The 412-L prototype system, built by General Electric, is now being readied for its initial operational tests this fall at RADC's facility in nearby Verona, N. Y.

For the 473-L system, which presently is in the early study phase, International Business Machines Corp. holds a contract to develop the operational specifications for the data-processing system, with RADC and other USAF organizations providing technical inputs. Preliminary systems planning prior to the contract with IBM had been carried out by RADC.

In addition to these major L-system responsibilities, the Control Systems Laboratory was responsible for developing a new family of frequency-diversity radars for use in the Continental Air Defense System (416-L). These new high-power radars, including the AN/FPS-24 and FPS-35, now entering field service, operate on widely separated frequencies and incorporate many other features intended to make them relatively invulnerable to enemy electronic countermeasures, according to Col. Bryant. The Control Systems Laboratory was responsible for establishing basic design parameters, preparing production specifications, supervising manufacture and testing of the experimental systems.

In the more exotic areas, this laboratory has conducted studies on the feasibility of establishing a space navigation system using radio/radar beacons located on the moon, according to J. M. Eannarino, chief of the laboratory.

The Directorate of Intelligence and Electronic Warfare consists of three laboratories:

• **Information Processing,** under F. J. Tomaini.

• **Electronic Warfare,** under E. N. Munzer.

• **Quick Reaction Capability,** under Major J. P. Moore.

This directorate has engineering responsibility for two Air Force command and control systems: Intelligence Data

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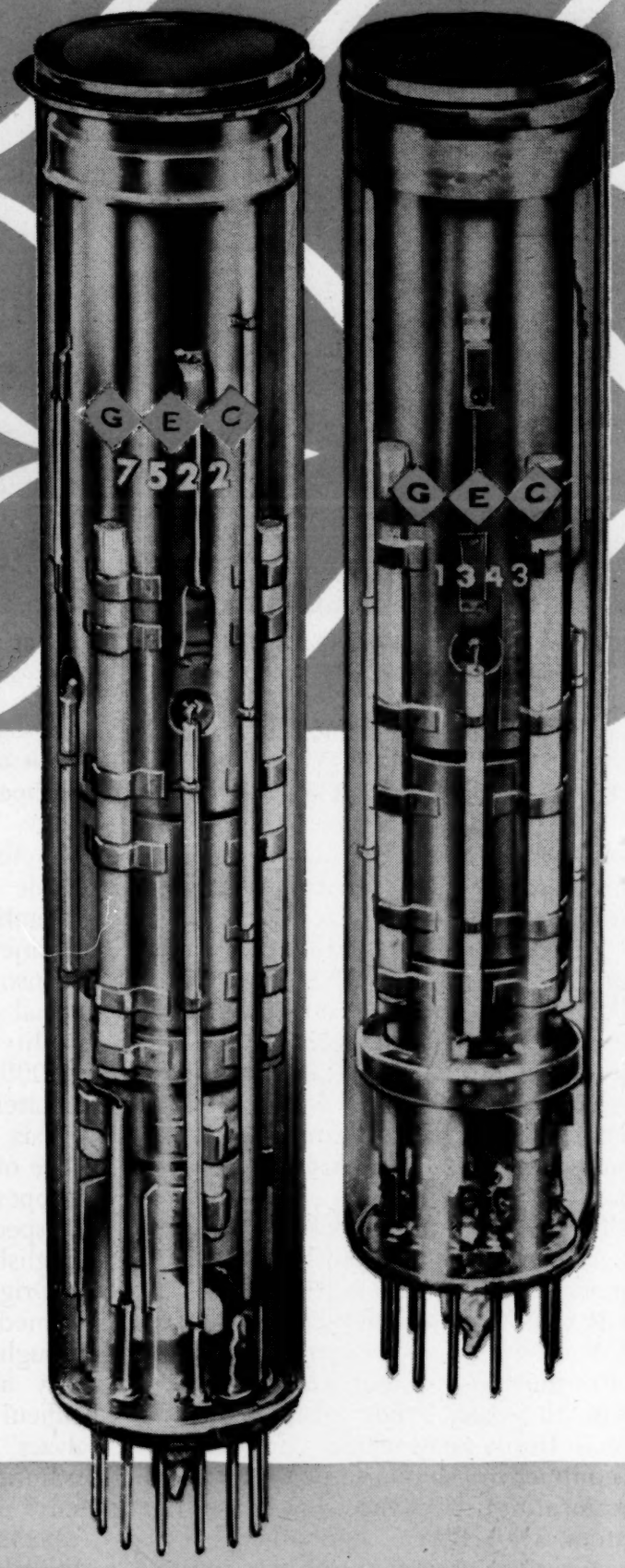

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MAN-MACHINE compatibility test is run at the Operational Applications Laboratory's surveillance simulator.

Handling System (438-L) and Electromagnetic Intelligence System (466-L).

The directorate has a total of about 235 people of which approximately 20% are military. Approximately 70% of the personnel are professional engineers or scientists. About half of the manpower is assigned to the Information Processing Laboratory, with the remainder about equally divided between the other two laboratories.

Information Processing

"Intelligence data may be obtained originally in many different forms—photographic, electromagnetic, textual, chemical, acoustic or other—but it usually ends up in textual form," according to Howard Davis, technical director of the directorate. Additionally, there is a considerable amount of raw intelligence information available in the open literature.

"For this reason, the main problem in intelligence data processing is the handling of textual data," according to Davis. This can be broken down into two types of effort: mechanical translation of foreign open literature and the library problem of storing, indexing and retrieving information both quickly and efficiently.

The need for automatic machine translation is pointed up by the fact that in 1959, the Air Force acquired an estimated 520 million words of Soviet technical literature, but was able to make full translations of only 23 million words, or about 5% of the total, according to Davis.

The Air Force, through RADC, has therefore sponsored programs in automatic machine translation, with considerable progress to date. International Business Machines Corp., under RADC sponsorship, has set up a small operational automatic language translation facility which is now translating up to 80,000 words per eight-hour day.

Literature is fed into the computer by six typists, without previous knowledge of Russian, who have been trained to operate a Russian character keyboard at speeds comparable to their normal English typing rates, Davis reports.

Originally the translations were performed on a "word-for-word" basis. Although this produces useful translations, they are rather crude and somewhat difficult to read. Recently, a "word analyzer" has been developed which can examine and translate a complete sentence rather than individual words. It is expected to be able to resolve previous difficulties with multiple-meaning words and be able to re-arrange word order in a sentence to conform to English language construction. As soon as the present IBM computer dictionary can be modified, the new word analyzer is expected to go into service in the USAF/IBM facility.

Another recent advance in automatic translation is a machine developed by Baird Atomic Co., under RADC sponsorship, which is capable of reading Russian (or English) text set in a variety of different type faces at speeds of seven pages per minute. This will permit greatly increased speeds of data entry into automatic translation machines.

Other RADC-sponsored programs in this field include a study of the problem of machine reading and translation of Chinese, the feasibility of spoken (voice) input for entering data into computers and a composing machine for inserting photos and formulas into translated copy in their proper locations. Such a machine is under construction and is expected to be available by the end of the year.

Severe Problem

The library problem of storing, indexing and retrieving information, already acute, will become even more severe with the advent of automatic translation of vast amounts of foreign literature, Davis points out.

RADC is sponsoring work in the use of computers to automatically prepare abstracts of articles and index them. Some success has been achieved, but some additional effort is needed to make automatic abstracting and indexing an operational reality, Davis says. Present plans call for testing several possible automatic indexing techniques in about a year, using several hundred thousand documents as guinea pigs for the techniques.

Currently under development by Thompson Ramo Wooldridge, under RADC sponsorship, is a machine called a "Word Searcher." It is expected to be capable of scanning printed documents at the rate of 10 pages per minute to determine if any one or combination of up to 20 selected words are present, noting the number of times the words occur and the sequence in

which they appear. Such a device would be extremely useful for up-dating old indexes or abstracts based on new areas of technical interest.

Despite the growing numbers and capacities of digital computers owned and operated by the Air Force, past experience shows that the demand for increased capacity usually outstrips the most conservative projections at the time the machines originally were obtained.

"Polymorphic Computer"

This has suggested a concept known as a "polymorphic computer" in which a number of individual computers, perhaps geographically separated by hundreds of miles, might be bound together by communications lines and operated, in effect, as a single extremely large-capacity machine. In the event of an unusually large peak workload, additional machines could be brought into the network.

The idea is patterned after the electric power networks created by some of the nation's public utilities to enable them to "borrow" electricity for short periods in order to handle peak loads.

Before the end of the current year, Thompson Ramo Wooldridge, working under RADC sponsorship, hopes to demonstrate the polymorphic computer principle by tying together several computers, each built by a different manufacturer—including a very large machine such as the IBM 7090 or the Control Data Corp. 1604.

As of July 1, RADC's group responsible for measuring vulnerability of radar and radio communications equipment to enemy countermeasures and interference from friendly equipment was transfered from the Electronic Warfare Laboratory to the Directorate of Communications. This shift reflects the increasing emphasis on communications and on reducing electromagnetic interference from friendly equipment.

Primary Effort

The primary effort in the Electronic Warfare Laboratory is now on electromagnetic reconnaissance equipment and subsystems. Little can be said about their details because of military security.

The broad objectives of current programs include pushing reconnaissance receiver operating frequencies upward in the millimeter band.

With this objective, the laboratory is sponsoring development of tubes for the millimeter band.

The Quick Reaction Capability (QRC) Laboratory, as its name implies, is intended to provide the Air Force with the capability of quickly designing and manufacturing limited quantities of equipment to meet urgent operational requirements in the electronic warfare or intelligence areas. This includes items from the electronics, optics and acoustics field.

When the quantity required is only one or two, the equipment frequently is designed and built here by RADC personnel.

For larger quantities, the effort is contracted out to firms which specialize in QRC work.

Approximately 95% of the equipment is delivered to the using commands within nine months of the time the requirement becomes known; often the delivery takes place within a few weeks.

Although communications long has been an important mission of RADC, it has never enjoyed greater prominence nor faced such challenging problems as it does today. In part this stems from the fact that all of the USAF's command and control systems lean heavily upon communications, in part from the exciting new possibilities opened up by space, and from the need to greatly increase the survivability of vital communication links.

Three Laboratories

The Directorate of Communications consists of three laboratories and a small systems engineering group.

These facilities are:

- **Advanced Development Laboratory,** under Albert Feiner.
- **Equipment Laboratory,** under Lt. Col. T. G. Williams.
- **Electromagnetic Vulnerability Laboratory,** under S. D. Zaccari.
- **Communications Planning Office,** under Charles A. Strom.

Despite the diversity of functions performed by the USAF's many command and control systems, they must be designed to use many of the same communications techniques and links, providing a point of common meeting. The function of the Communications Planning Office is to provide the System Program Offices at Hanscom Field with engineering specialists in communications.

Within this office are about 14 engineers. Each is assigned to a different L-system, working with his assigned SPO, analyzing its communication needs to determine whether new developments are needed and which of the existing techniques would prove to be best.

A small group within this office is responsible for overseeing the communications needs and capabilities of all the L-systems across the board to apply solutions developed in one program to the requirements of another program.

The L-system specialists assigned to the SAC Control System (465-L) and to AirCom System (480-L) also are responsible for coordination of all portions of the RADC effort which includes data processing and display operations.

A variety of communication techniques which five years ago would have been considered exotic now is under active investigation by the Advanced Development Laboratory, aimed at improving survivability and reliability of vital Air Force communications. Approximately half of the laboratory's effort is contracted outside, the other half is in-house, according to Albert Feiner, Advanced Development Laboratory chief.

Representative of the type of advanced communication techniques under study or development by the laboratory are the following:

- **Semi-passive communication satellite** which would combine the simplicity and long-lived reliability of an Echo-type sphere but with moderate signal enhancement. Several such techniques are under study by RADC and outside contractors. One, proposed by Space Technology Laboratories, would use an active Van Atta array of thin deposited metal elements with tiny semiconductor parametric amplifiers powered by solar cells and thin wafer-type mercury batteries. Such a satellite might provide about 10-db. gain over an isotropic Echo type sphere, according to Feiner. Radioplane Division of Northrop is investigating another type under RADC contract. It would use the Bragg reflection principle in which the satellite surface would be coated with suitable material in which internal reflections of the radio signal would produce signal enhancement.
- **Distributed aperture antenna systems,** using several physically displaced steerable parabolic antennas suitably phased to provide performance equivalent to that of a much larger antenna, is under investigation by Ohio State University's Antenna Laboratory under RADC sponsorship. By next summer, the university plans to have an experimental array of four 30-ft. diameter parabolic antennas, spaced 60-ft. apart, expected to provide the gain of a 60-ft. parabolic dish at S-band.

This concept appears to present a number of significant advantages, according to Feiner. Smaller antennas are easier, less expensive to fabricate to precise tolerances than larger sizes. Furthermore, the smaller antenna dishes can operate at lower elevation angles, an advantage for communication satellite tracking. Additionally, it is easier to harden a smaller antenna installation.

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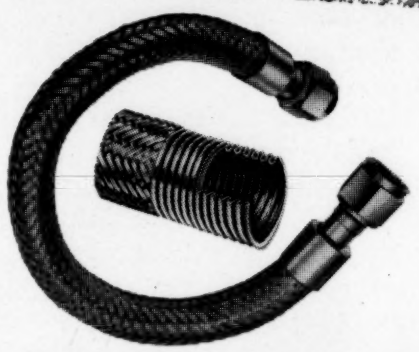

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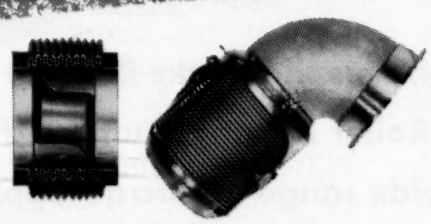

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ing proper phase relationships between individual antennas, but this is not expected to be a problem (AW Aug. 21, p. 54).

• **Low-noise amplifier developments,** such as masers, are being sponsored by this laboratory. One promising new low-noise amplifier concept is a continuous-wave device using a solid as the active medium, which is expected to operate at frequencies of 80 kmc., and higher. Developed by Technical Research Group, Syosset, N. Y., the new device is soon to undergo its first tests. It will require cooling to liquid helium temperatures, but needs no magnet (as does a maser) except for tuning. Pump frequency is practically identical to the signal frequency.

• **Mobile communication** satellite terminal, under study, would consist of an inflatable 15-ft. diameter antenna and a modest-power transmitter mounted in an air transportable van to serve as a mobile terminal. Using a 60-ft. antenna and more powerful transmitter as a fixed terminal, the system should provide useful ranges of 3,000 mi. using an Echo type satellite.

During the coming year, the Advanced Development Laboratory expects to conduct extensive in-house and contracted studies of the problem of communication satellite network discipline, i.e., what station would use which satellites at what times in a multi-station network and optimum switching and modulation techniques.

RADC Contract

Under RADC contract, Bell Telephone Laboratories is investigating possible military uses for the Project West Ford technique, developed by Lincoln Laboratory, which would create a belt of millions of tiny dipoles in orbit that would serve as an artificial ionosphere for long-range communications at S-band and X-band line-of-sight frequencies. The study includes an analysis of the number and location of stations required to provide Air Force global communications, anti-jamming techniques and network user disciplines.

The Communications Directorate's Equipment Laboratory is primarily equipment and hardware oriented, where the Advanced Development Laboratory is primarily techniques oriented, but there is a natural amount of overlap between the two areas of research.

The Equipment Laboratory is responsible for keeping abreast of new hardware developments and providing direct support to L-system SPOs on specific communications equipment going into these systems. This includes preparation of specifications and working with L-system contractors for communication subsystems.

About half of the laboratory's effort goes into such direct support and about one-third is devoted to applied research in investigating and evaluating new techniques and equipment, according to Lt. Col. T. G. Williams, lab chief. Most of the remainder of the effort is in support of the Rome Air Materiel Area (ROAMA), for devising improvements and modifications for hardware already in use and for L-systems equipment procurements.

Some of this laboratory's typical in-house investigations include the following:

• **VLF propagation tests** to determine how well radio signals in the 10 to 20 kc. frequency range can be transmitted over extremely long distances reliably using the effective wave-guide formed by the underside of the ionosphere and the surface of the earth. Tests are now under way five miles at sea off Ft. Pierce, Fla. which will use a transmitter located on a boat and an antenna consisting of a wire which is hoisted by balloon to altitudes of 10,000 to 20,000 ft.

A related project, part of the Vela Uniform program (sponsored by Advanced Research Projects Agency) to develop techniques for detecting clandestine nuclear tests, will measure propagation of low frequency (10 kc.) radio signals at distances of several miles below the earth's surface. Such low frequency signals are believed to be generated by underground nuclear explosions (AW July 17, p. 63).

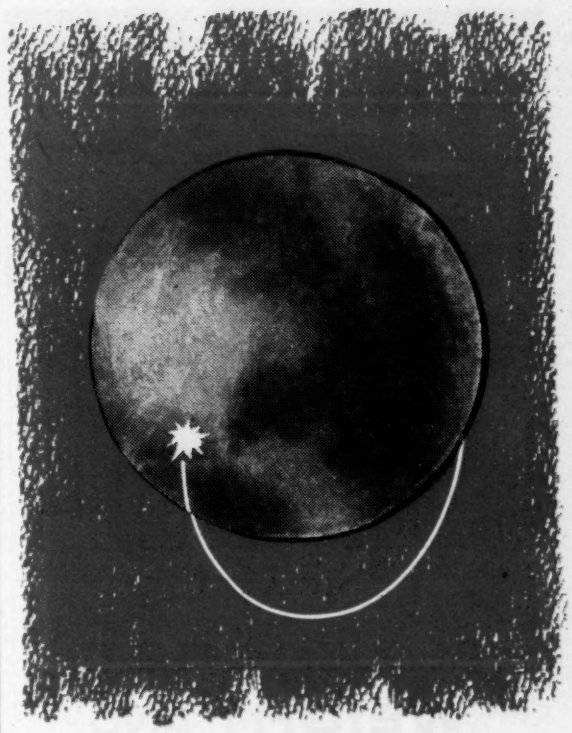
• **Survivable long-range** communications using shallow earth-current techniques with buried antennas have been demonstrated over distances of 1,200 mi. at frequencies below 40 kc. The radio wave propagates along the interface between the ground and the adjoining atmosphere.

• **Hardened antenna structures** presently are under study by Space-General Co., and RADC hopes to have additional funds in Fiscal 1962 for increased number of such programs, according to Lt. Col. Williams.

Williams says the laboratory is sponsoring fewer independent equipment developments by industry than in the past, primarily because such work is being sponsored now by L-system SPOs for specific system applications. However, there still is some breadboard-experimentation hardware procurements to evaluate new techniques.

Interference Problems

Within very recent years, it has become apparent that the mushrooming use of radar, radio communications, air navigation and other radiating electronic equipment in the U.S. military establishment may cause serious interference problems between such equipment in a combat situation. There are some who suspect that unintentional interference from friendly equipment may prove



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The establishment of the Electromagnetic Vulnerability Laboratory, under Samuel D. Zaccari, in the Communications Directorate reflects the broader mission of reducing vulnerability both to friendly and enemy electromagnetic radiation.

Verona Facility

This laboratory operates a test facility at nearby Verona, N. Y., which contains a variety of ground radars, representative of those now in use by Western powers and covering the frequency spectrum. Aircraft outfitted with the latest types of airborne electronic countermeasures and jamming equipment are flown in missions simulating enemy action, while RADC personnel evaluate the effectiveness of the counter-countermeasures capability built into ground radars and new techniques for improving this capability. The facility also is used to measure mutual interference between ground radars and communication equipment.

Also part of the Verona facility is a dynamic antenna pattern measuring equipment, the AN/MSQ-16, which can be used to obtain accurate data on the radiation pattern of airborne radar, ECM and other antennas from aircraft in flight. The facility covers the frequency range from 60 to 11,000 mc. and also can be used for generating signals to test airborne radars and for passive detection/vulnerability tests of airborne navigation systems.

Less dramatic but of equal importance are the Electromagnetic Vulnerability Laboratory's many study programs aimed at better fundamental understanding of the two-edged vulnerability/compatibility problem.

A representative sample of the programs includes:

- **Automation of ground-based** spectral measurements, to permit rapid acquisition of field intensity and antenna pattern measurements for the Defense Department's compatibility analysis center.
- **Interference parameters in** satellite communications, due to tracking errors, orbit perturbations, plasma phenomena, doppler shift and other factors, is under study. Program includes experiments to measure ambient signals (from outside natural and man-made sources) scattered by Project Echo type satellites. End objective is to provide a means for evaluation of different proposed communication satellite designs in terms of performance and compatibility.
- **Model techniques** for interference measurements, to determine if radiation pattern measurements of extremely large antennas, which are difficult to obtain, could be determined with sufficient accuracy from a small model of the antenna, using acoustical, radio frequency and/or optical techniques.

The Directorate of Engineering, under William Bethke, has two principal missions: applied research and development in displays, reliability and other techniques applicable to a variety of RADC efforts, plus engineering support to the other RADC directorates in those areas where a single centralized capability is more efficient.

The Engineering Directorate has a total staff of about 240 people, of whom roughly one-half are professional engineers and scientists. These include electrical, mechanical, civil, chemical, ceramic and metallurgical engineers plus mathematicians and psychologists.

The bulk of this directorate's programs are in-house efforts and it has only modest funding for outside contracts, according to Bethke. About one-third of the personnel is engaged in applied research and development engineering programs, half of whom are working on in-house projects. Another 25% of the total personnel performs mechanical engineering, structure design, human engineering and similar across-the-board services for the other directorates. An equal number is engaged in preparation of specifications and purchase requests for RADC and ROAMA procurements, while the balance of the personnel is clerical and administrative.

The Directorate of Engineering consists of three laboratories:

- **Applied Research,** under Joseph J. Naresky.
- **Development Engineering,** under Daniel R. Loreto.
- **Human Engineering,** under Dr. Carlo P. Crocetti.

All of the across-the-board support functions are concentrated in the Development Engineering Laboratory, except for human engineering.

Applied Research

Generally speaking, advanced research and development which has no specific timetable, i.e. is not associated directly with a specific L-system program, is assigned to the Applied Research Laboratory, while scheduled efforts generally are assigned to the Development Engineering Laboratory.

In the case of displays, all three laboratories are involved, but the Applied Research Laboratory is responsible for investigating new display techniques. One current in-house effort is aimed at developing a light modulator for dynamic (real-time) large screen display of such information as a fast-changing air defense situation.

One technique under investigation employs a solid crystal of ammonium dihydrogen phosphate inserted between a light source and lenses of an optical projector. The crystal will block the

passage of light except at those points where it is exposed to electromagnetic energy. By using an electron gun to produce a beam of electrons which impinge on the face of the crystal, and using familiar electron beam deflection techniques, any desired display can be "written" on the crystal which in turn will permit passage of light in an identical pattern through the projection system onto a display screen.

The laboratory recently has set up a micro-electronics facility which will enable it to experiment with vapor and chemical deposition techniques. One of its current efforts involves the development of a photo-conductive switching element such as that needed for electroluminescent displays.

This new facility also will serve to provide a nucleus of micro-electronics know-how within RADC, enabling its scientists to follow and better appraise new developments in this fast-moving field.

Optical Masers

Laboratory scientists here are beginning to experiment with optical masers to learn more about the properties of this new development and to explore its possible use as a combination amplifier-display device.

In one series of tests, using 10 copies of each of 20 different "preferred circuits," there have been only two circuit failures in an accumulated total of 70,000 circuit operating hours, according to Bethke.

Another area under investigation by this laboratory deals with techniques for increasing the survivability of mechanical structures and electronic equipment in a nuclear environment. The Development Engineering Laboratory also is working in this area, but with its efforts directed toward specific L-systems under development.

The vastly increased power of new radars is placing increased emphasis on the radiation hazard investigations sponsored by the Development Engineering Laboratory. The Air Force has been assigned responsibility for study of electromagnetic radiation hazards to personnel while the Navy is investigating the hazard to fuel, rockets and munitions.

Practically all of the RADC effort in this area is conducted under contract by universities.

The Development Engineering Laboratory also is responsible for development and evaluation of electronic security devices used to warn of intruders near an aircraft, missile site or within a security area. "In the process of evaluating a number of commercially available security devices to see if they can be foiled, we've developed some pretty good burglars," Bethke says. Most of the systems tested fall short of USAF's needs, he says.

A small group of experimental psychologists in the Human Engineering Laboratory, headed by Dr. Carlo Crocetti, is conducting a number of important investigations intended to point the way toward improved displays and more efficient transfer of information from data processing machines to human operators.

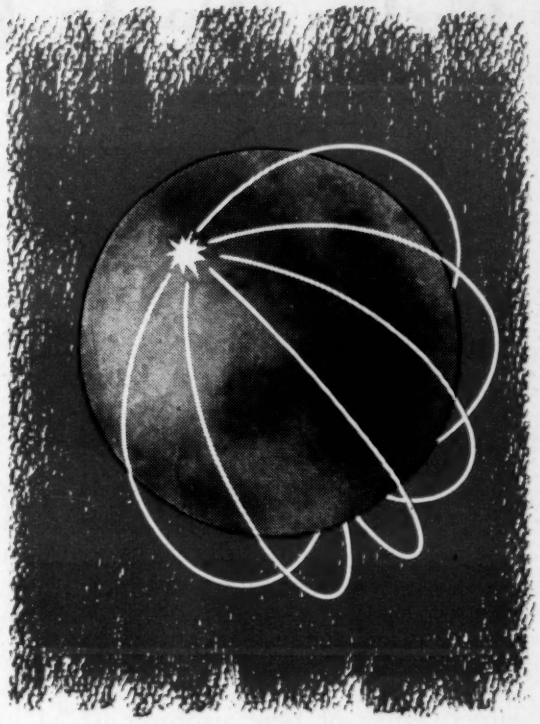
A few representative investigations under way at the Human Engineering Laboratory include the following:

- **Tactile speech transmission,** in which human speech is received by a human operator through his skin which is in contact with a vibratory mechanism. Using specially processed human speech, which first is slowed down by a factor of 8:1 from normal, then compressed by chopping out pieces of the sound at regular intervals, subjects have been able to "hear" sounds through their skin.
- **Human operator saturation studies,** now under way, are intended to determine if it is the human sensors (eye, ear) or the brain which saturates first. If the eye or ear saturates before the brain, then the use of several different input channels in combination (eye, ear and touch) would enable human operators to operate at higher work loads. If, on the other hand, the brain saturates first, then there is no gain from using multiple data input channels.
- **Speech intelligibility tests** have been developed by the Human Engineering Laboratory which can be used to obtain a quantitative measure of the quality of competitive communication equipment and techniques. The intelligibility tests also can be used to pinpoint the weakest links in a communication system from an intelligibility standpoint.
- **Photo interpretation tests,** intended to determine how much "blur" can be tolerated without loss of depth effect in analyzing aerial photographs by stereo techniques, have revealed that human operators can do remarkably well with badly blurred photos, according to Dr. Crocetti. The results of these tests will be useful in establishing performance limits needed on aerial and space reconnaissance photographs.

Advanced Studies Office

Under RADC's Deputy for Plans and Operations is the Advanced Studies Office which prepares long-range plans for RADC research and development programs based on military operational requirements for the 1965-75 period.

The Advanced Studies Office, headed by Dr. I. J. Gabelman, and staffed by four senior scientists, with assistance of personnel from other RADC directorates, conducts in-house studies in such fields as defense against mass-ICBM attack, space surveillance and secure space communications.



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Eglin Tests Electronic Support Systems

Eglin AFB, Fla.—Air Proving Ground Center mission is changing, with increasing emphasis on test of electronic support systems as the work load in evaluating air-breathing weapons, air-launched missiles and fire-control systems declines.

Many of the same geographic factors which made Eglin AFB an ideal location for testing new weapons are also important for its new assignments in evaluating electronic support systems.

The Air Proving Ground Center (APGC), under Maj. Gen. Robert H. Warren, is heavily engaged in the integration of the Bomarc interceptor missile into the SAGE air defense system, in evaluating new high-power frequency diversity early warning radars and their ability to resist enemy countermeasures. Additionally, APGC is evaluating the effectiveness of new airborne ECM intended for use by Strategic Air Command bombers.

By next summer, APGC expects to be engaged in Category II tests (joint USAF-contractor) of the new Air Weapons Control System (412-L). Evaluation will be conducted in cooperation with the Tactical Air Command in the Myrtle Beach, S. C., area.

The APGC location on the Gulf coast of the Florida panhandle provides an overwater range approximately 400 mi. long in a southeastern direction. The west coast of the Florida peninsula provides a series of convenient sites for locating tracking radar and telemetry stations to instrument the range.

Approximately $70 million has been invested to make this Eglin Gulf Test Range (EGTR) into a huge laboratory which can provide the precise measurements needed to evaluate the performance of air defense and offensive weapons and systems.

The APGC also carries out small atmosphere and space probe launchings using such vehicles as the Astrobee 500, the Aerobee 300 and the Nike-Nike Cree, which are fired in a southwestern direction, permitting ranges of more than 500 mi. Nearly 200 rocket probes have been launched by APGC with a high percentage of successful shots.

The growing role for APGC in evaluating electronic support systems is a direct outgrowth of the decision made several years ago to transfer tests of the Bomarc missile to Eglin to ease congestion at the Atlantic Missile Range. The facility here was a logical place for such operations because APGC had extensive background in testing operationally similar interceptors and their semi-automatic fire control systems against drone targets.

Peacetime Launches

The Bomarc launch facility constructed on nearby Santa Rosa Island, known as Site A-15, directly on the Gulf, is the only site from which such missiles are launched in peacetime exercises. For this reason, it also serves as a training center and refresher facility for Air Defense Command crews that man the operational Bomarc sites.

Despite many similarities between the Bomarc and previous manned interceptors tested here, there are also significant differences. Where the manned interceptor was basically a self-contained weapon, the Bomarc operates as an integral part of the SAGE air defense system which controls the Bomarc's launch and its guidance to the vicinity of the target.

Another fortuitous geographic factor is the SAGE sector control center located only 150 mi. north of Eglin at Gunter AFB, near Montgomery, Ala. In addition to providing APGC with a conveniently located operating SAGE center for Bomarc tests, the joint arrangement enables Air Defense Command personnel to gain early operational experience with the new weapon.

Radar Tests

Within the past year, a new family of frequency-diversity radars, developed as potential replacements for older air defense radars, became available for evaluation to determine their performance as an input to SAGE and their resistance to enemy electronic countermeasures (ECM).

In the past, the Boston area has been used for SAGE experimentation because of its proximity to Lincoln Laboratory which conceived SAGE and monitored its development. However, such experimentation tends to divert the facility from its operational air defense mission, and the Northeast area contains many strategically important target areas.

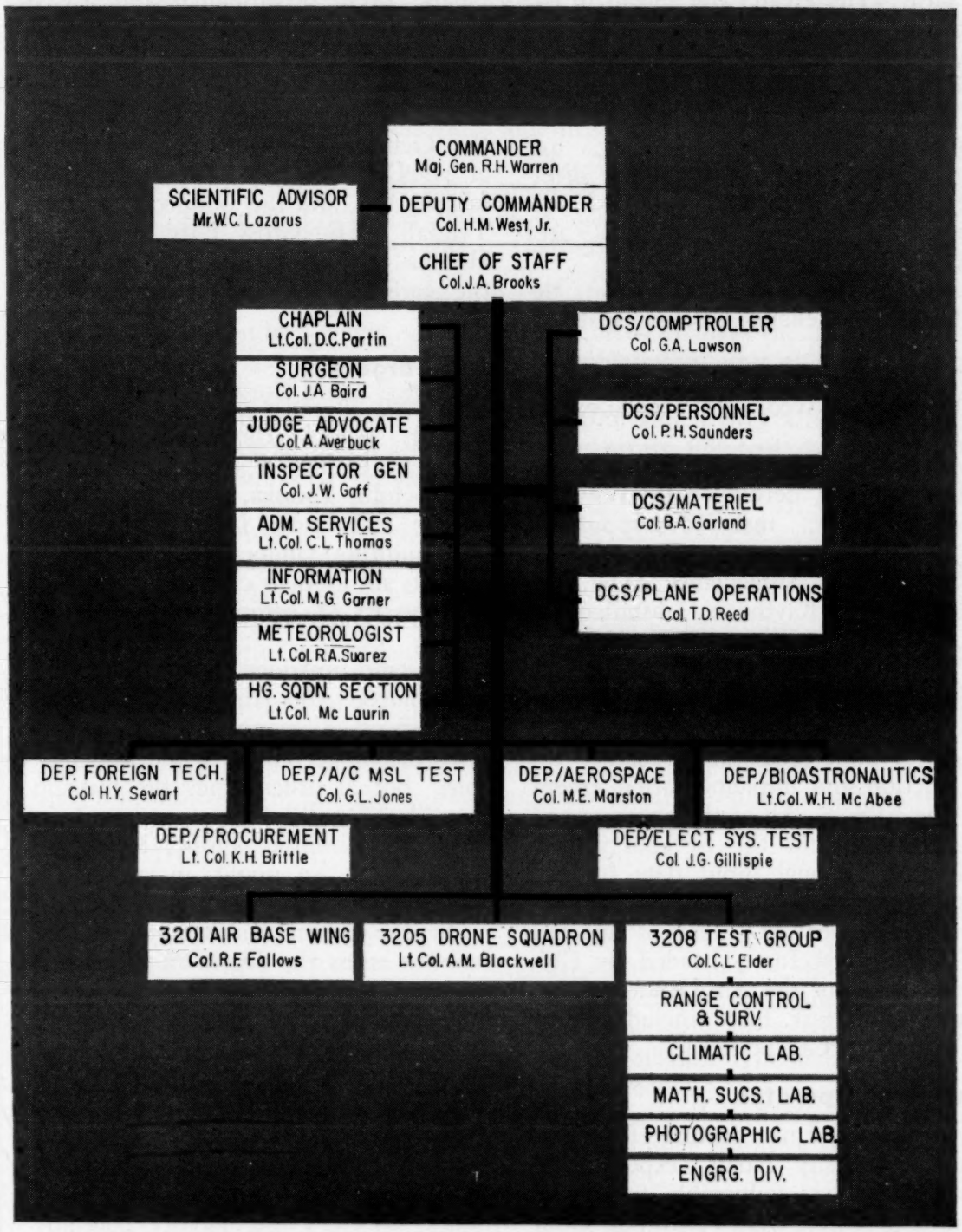
For this reason, it was decided to shift the tests of the new frequency diversity radars to the Montgomery sector. Another important reason for the shift was that ECM equipment used to test the anti-jam features of the new radars might seriously disrupt vital military or civil radio/radar services in a highly industrialized area such as Boston.

Electromagnetic warfare is not a new field for APGC. For many years it had evaluated bomber defense systems, from the manned gun turrets of early World War II through the radar-directed gun turrets of the postwar period. With the advent of rockets and guided missiles as interceptor weapons, there has been a shift in bomber defense from "hard" armament to the "soft" defense systems of electronic countermeasures, intended to confuse or deceive interceptor radars and missile guidance systems. This shift was reflected in the growth of capability here in electronic countermeasures evaluation techniques.

APGC Organization

Although the avionics activities of APGC permeate all six of the major operating groups, the electronic systems evaluation effort is centered under the Deputy for Electronic Systems Test, Col. Joseph Gillespie and technical director Frank Kabase. The other five deputies include the following:

Maj. Gen. Robert H. Warren, Commander, Air Proving Ground Center, AFSC . . . born Yankton, S. D., 1917 . . . graduate U. S. Military Academy, 1940 . . . received pilot wings at Maxwell Field, Ala., 1941 . . . flew B-18s and B-17 . . . went overseas with 14th Air Force and flew 38 combat missions . . . in mid-1945 was assigned for training on B-29s . . . duties in Hqs. Army Air Forces until mid-1949 . . . Air War College, 1950 . . . Hqs. FEAF as Director of Operations, then assistant deputy for operations, 1953 . . . assigned various executive positions at USAF Hqs., 1959 . . . vice commander, Air Proving Ground Center, 1960.



AIR PROVING GROUND CENTER

- **Aircraft and Missile Test:** Col. George L. Jones.
- **Aerospace:** Col. M. L. Marston.
- **Bioastronautics:** Lt. Col. W. H. McAbee.
- **Foreign Technology:** Col. H. Y. Sewart.
- **Procurement:** Lt. Col. K. H. Brittle.

Under the Deputy for Electronic Systems Test are four directorates, two of which are heavily involved in ECM:

- **Frequency Diversity Radar.**
- **Electromagnetic Warfare.**
- **Air Weapons Control System.**
- **SAGE Integration.**

The Frequency Diversity Radar and the Electromagnetic Warfare Directorates play opposite roles in electronic warfare. The former seeks to evaluate the effectiveness of our newest ground radars in resisting ECM efforts to disrupt their function, while the latter tests the effectiveness of our new airborne countermeasures equipment against ground radars.

Because of differences between U.S. and Soviet ground radars, special ground radars must be fabricated to simulate the characteristics of the threat that our airborne ECM is intended to counter, while special airborne countermeasures equipment must be constructed to use in tests against our new U.S. ground radars.

The Electromagnetic Test Environment used in this APGC evaluations consists of more than a dozen different types of ground radar, some U.S. types, some representing potential threats. In some instances, the effectiveness of an airborne ECM equipment may be evaluated against as many as 15 radars in a single test.

The basic philosophy behind the new frequency diversity radars is a simple one. If any given volume of airspace is under surveillance by two or more radars, each operating at a different frequency, and if each is able to quickly shift its operating frequency, it becomes extremely difficult for an enemy bomber to continuously and effectively

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jam all of the ground radars simultaneously. The greater the spread in frequency between individual radars and the greater the "agility" of individual radars in switching frequency, the more difficult is the task of the airborne jammer.

The new family of frequency diversity radars now installed in the Montgomery Air Defense Sector/APGC area includes the following:

- **AN/FPS-24:** Surveillance radar, developed by General Electric, installed at Eufaula, Ala.
- **AN/FPS-26:** Height-finder radar, developed by Avco, also installed at Eufaula.
- **AN/FPS-27:** Surveillance radar with 3-D capability, developed by Westinghouse Electric, installed at Crystal Springs, Miss.
- **AN/FPS-28:** Surveillance radar, developed by Raytheon, installed at Houma, La.
- **AN/FPS-35:** Surveillance radar, developed by Sperry Gyroscope Co., located at Thomasville, Ala.

All of these radars are scheduled for production and implementation except for the FPS-28. All of the above equipment, except for the FPS-28, is providing operational input data for the Montgomery SAGE center. Evaluation of the new FD radars is directed by a joint test force, headed by Col. S. K. Briggs of the Air Defense Command. The task force includes both ADC and APGC personnel.

Anti-Jam Operator

An important new feature of the frequency diversity radars, expected to make them less vulnerable to enemy countermeasures, is an "Anti-Jam Console," manned by an electronic counter-countermeasures (ECCM) operator, sometimes dubbed "Captain Video."

The console provides the ECCM operator with extremely sensitive radar receivers and spectrum analyzers which enable him to quickly determine the important characteristics of any ECM signals and to demonstrate different ECCM fixes to determine which is most effective in countering the threat.

In the FPS-27, built by Westinghouse, the anti-jam console provides three separate radar scopes. One displays the raw incoming data including jamming signal. A second scope and related controls serve as a sort of "work bench" where the operator can try out several different ECCM fixes to find the best one. The third scope displays the final signals, after being processed by the selected ECCM fix, which are then transmitted to the SAGE computer.

Using this console, the anti-jam operator can introduce a quick fix while he continues to experiment to see if a better one can be achieved.

In APGC tests on the new FD radars, their performance and ECM vulnerability can be compared directly with existing air defense radars installed in the same area and used as SAGE input sources. These include the General Electric FPS-7, installed at MacDill AFB, Fla. and at Dauphin Island, Ala., and the Bendix FPS-20 at Tyndall AFB, Cross City, Fla., and Houma, La. The FPS-7 was one of the earliest U. S. frequency diversity radars.

Jet Targets

In tests of radar coverage, small jet aircraft, such as the F-104 and the T-33, are employed as targets, according to John Zwaska, technical adviser to the FD Radar Joint Test Force. For jamming vulnerability tests, KC-135 jets are used to carry the variety of airborne ECM equipment that is required.

In some missions where jamming is employed, the jammers operate in a pre-specified manner to provide a basis for comparison with previous missions. But at other times the mission is a "free-for-all" type experiment in which the airborne jammer is free to improvise as he might in an actual military operation, according to Zwaska.

On the ground, measurements are made to assess the degree to which the jamming degrades both the raw video data, presented on radar scopes, and the processed data after it has been converted into digital form for transmission to the SAGE computer.

To permit side-by-side comparison of the relative merits of different radar signal processing and anti-jam techniques, APGC's test facility contains 10 console scopes. These can display radar signals which have been processed by a different technique. Operators at each console, all viewing the same air-battle situation, record the maximum range at which the target is first detected without jamming and when it first is obscured by jamming. These and other observations are recorded on punched cards to permit subsequent computer analysis and comparison of competitive techniques.

APGC Recommendations

As a result of tests conducted to date, APGC has recommended the elimination of certain anti-jam features in the production models of the new frequency diversity radars because they do not appear to justify the added cost and complexity, Zwaska says.

Within the next few months, the first attempt will be made to jam the entire frequency-diversity radar complex, or SAGE sector. Previous tests have been run against individual radars within the sector.

The Electromagnetic Warfare Di-

rectorate, under Lt. Col. George Nickerson, has developed techniques which make it possible to obtain a quantitative appraisal of the relative effectiveness of airborne ECM equipment, according to Eugene J. Pollock, technical director.

Many types of airborne ECM can provide some degree of protection for a bomber over enemy territory, by degrading enemy radar performance. But every additional ECM black box carried cuts down bomber range, speed and/or payload, so the objective must be to obtain maximum protection for the bomber at minimum over-all cost.

Until recently there has been a tendency to rely upon subjective appraisal, or what is termed "eyeball data," for evaluating the effectiveness of different types of ECM equipment. The evaluations conducted by APGC seek a more scientific appraisal, based on what is called "blip/scan ratio" and "deniability factor."

The blip/scan ratio is the number of useful target blips obtained divided by the number of ground radar antenna scans. For example, if natural causes or jamming obscures some target echoes so that an average of only four blips are obtained for every 10 scans, then the blip/scan ratio would be 40%.

Deniability Factor

The deniability factor, a measure of the effectiveness of an ECM equipment, is defined as the blip/scan ratio with no jamming minus the blip/scan ratio with jamming, divided by the blip/scan ratio with no jamming. For example, if the blip/scan ratio without jamming is 95% and the blip/scan ratio with jamming is 40%, then the deniability factor would be 58%. Another type of jammer, which reduces the blip/scan ratio to 20%, would have a deniability factor of 79%, under the same conditions.

In evaluating the effectiveness of new airborne ECM equipment, APGC normally uses a minimum of 15 different ground radars, some of special design that are representative of threat radars. The collection of ground radars covers a broad expanse of the radio spectrum.

The aircraft carrying the airborne ECM equipment flies a cloverleaf pattern which brings it within range of all of the ground radars at specific aspect angles. The airborne jammers are turned on at three different distances from each ground radar and performance measurements are made. To assure that the airborne jammer flies a prescribed track, to permit correlation of performance between different runs, the aircraft position is precisely established by means of AN/FPS-16 tracking radars, produced by Radio Corp. of America.

Because the strength of signal return from a target can change sharply with small changes in the target aspect angle relative to the radar beam, and because the radiation pattern of airborne ECM antennas also depends upon aspect angle, aircraft position and heading must be precisely controlled during the tests, Pollock points out.

Atmospheric conditions also can alter the performance of the radar and the airborne jammer. For this reason, APGC often changes the airborne jammer configuration after each run during a single test to avoid atmospheric effects. But similar runs will be repeated on five or six different days so as to include changing atmospheric effects.

Five Receiver Types

Each of the ground radars may be outfitted with up to five different types of receivers to determine how well the ECM can counter different anti-jam techniques of radar designers.

Because of the many variables which may affect ECM performance, including aircraft configuration and ECM antenna layout, Pollock says that it is important to test a complete airborne system on the aircraft in which it will be used.

It is far easier to measure the effectiveness of airborne ECM on automatic tracking radars, such as those used for interceptor fire control and for guidance of surface-to-air missiles, than it is for surveillance type radars, according to Pollock.

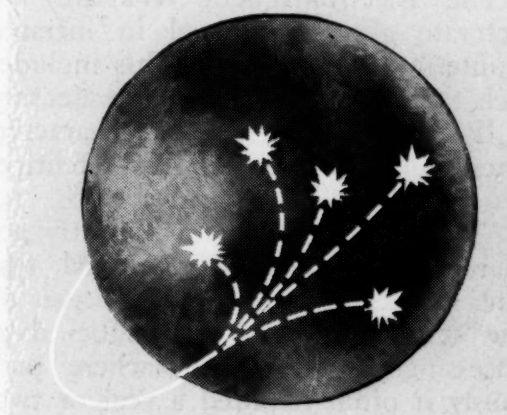
To measure the effectiveness of an airborne jammer against a surface-to-air missile target tracking radar, APGC uses both an FPS-16 and the "victim" radar to track the target simultaneously.

When the jamming equipment is turned off, the FPS-16 determines target position with extreme accuracy. This is compared with target position as determined by the victim radar, to establish unjammed tracking error of the victim radar.

The airborne ECM equipment operates at a frequency which interferes only with the victim radar, so that FPS-16 performance is not degraded. When the airborne jammer is turned on, any increased error in the victim radar tracking is a direct measure of what effectiveness the jammer possesses.

Chaff Testing

The passive-type ECM, known as chaff, is evaluated here by APGC to determine if it can be dispensed effectively from a high-speed aircraft and whether it provides protective screening for the aircraft. Ground radars are used to measure the "bloom history" of dispensed chaff, that is, how its reflecting characteristics and shape change with time after being dis-



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To find out more about the radio-command guidance system, write to Section 170, Defense Systems Department, General Electric Company, Syracuse, New York.

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pensed. Other tests are run to determine if chaff can cause automatic tracking radars to "break lock" on the specific target.

The Electromagnetic Warfare Directorate also is engaged in infrared countermeasures testing. This includes such things as measuring the trajectory of IR devices, their radiation characteristics and also their over-all effectiveness.

APGC has been able to greatly accelerate the evaluation of ECM systems and equipment with the use of new techniques and automatic data processing. For example, where previously it often required a year or two to test a major system, today it can be done in several months, Pollock says.

Air Weapons Control

The Air Weapons Control System Directorate, under Lt. Col. William D. Jones, is responsible for drawing up the test plan which will be used to evaluate the military characteristics and suitability of the 412-L system when it starts its Category II tests next summer at Tactical Air Command Headquarters.

The 412-L system currently is being readied for its Category I tests by Rome Air Development Center and General Electric at the RADC Verona, N. Y. facility.

The Air Weapons Control System, sometimes referred to as "Little SAGE," is intended to be an air-transportable system for overseas bases to control fighter-bombers during part of their mission and to provide air defense for such bases.

The 412-L system will use two types of Westinghouse radars, the TPS-22 and TPS-27. The latter is a 3-D type which provides height information. Also included is the GPA-73 data processor and display, built by General Electric, and associated communications links.

The Category II tests scheduled for next year will include a mobility evaluation in which system will be dismantled, transported to another site and set up for operation, according to Lt. Col. Jones. These tests also will serve to develop TAC operational procedures for using this highly automated system.

Management Responsibility

Over-all management responsibility for both Category I and II tests is assigned to APGC, with RADC serving as technical manager for conduct of the Category I tests with GE. APGC personnel currently are stationed at the Verona site and at nearby Watertown, N. Y., where system radars will be located.

The SAGE Integration Directorate is a joint APGC/Air Defense Command group, currently headed by Col. K. E. Hill of ADC. It also includes a systems engineering group provided by The Mitre Corp.

While the responsibility for Category I and II testing of Bomarc—both "A" and "B" models—and its direct support and launch subsystems, is assigned to the Aeronautical Systems Division Bomarc Field Test Unit here at Eglin, the SAGE Integration Directorate is responsible for the mating of the missile to the SAGE system.

This integration effort can be described in terms of three broad objectives:

- **Subsystem functional testing:** Several major subsystems serve as interconnecting links between SAGE and the Bomarc missiles it controls. These include the data link by which SAGE computer guidance instructions are transmitted to the missile, the Mark X missile-borne radar beacon which aids SAGE radars in tracking Bomarcs in flight, and a pre-launch subsystem which enables a SAGE control center to determine the status of each Bomarc, ready it for launch and fire the missiles from sites located several hundred miles away.
- **Subsystem integration:** This involves the development of SAGE computer programs for operation of these functional subsystems.
- **Demonstration of capability:** This encompasses actual test firings under SAGE control, dress rehearsals which use manned aircraft outfitted with Bomarc guidance, and mission modeling.

Bomarc Cost

Because of the cost of Bomarc missiles, it is not feasible to fire large numbers in a variety of different attacks to obtain a fine-grained performance profile.

Instead, the Integration Directorate is attempting to develop a mathematical model, based on a few actual launches, which can be used to accurately predict missile performance for any conceivable mission profile.

Based on current experience with the Bomarc A, it appears that an accurate model can be developed, according to Daniel F. Casey, who is technical adviser to the SAGE Integration Directorate.

Different models must be developed for the Bomarc B because the missiles fly different mission profiles and the SAGE computer program employs different control characteristics, Casey says.

The Mitre systems engineering group here establishes test procedures used in system tests.

The Eglin Gulf Test Range covers 18,000 sq. mi., an area larger than Switzerland. Over this area, APGC must provide precision radar coverage for accurate determination of the position of the drone target and Bomarc missile, telemetry for transmission of important missile performance parameters, radar and radio for guidance of the drone target, and data link coverage for guidance of the Bomarc itself from the Montgomery Air Defense Sector.

The range also is used for evaluations of a variety of air-launched missiles, including the GAM-72 Quail (decoy), GAM-77 Hound Dog, GAM-83 Bullpup and for drop tests involved in the GAM-87 Skybolt air-launched ballistic missile development.

Radar Locations

A total of 12 AN/FPS-16 radars are located at four sites to obtain accurate data on missile and drone target location for subsequent analysis. Four of these are located at Site A-20, directly north of the Bomarc launch site, three at Cape San Blas (about 80 mi. east of A-20), another three FPS-16s at Anclote Point (near Tampa), and two are situated on Marco Island, about 60 mi. above the southern tip of the Florida peninsula.

The QB-47 drone aircraft currently used as Bomarc targets are controlled from Site A-3 on Santa Rosa Island, east of the missile launch site. A series of S-band radars, MPS-19, MPS-9 and MPQ-31, at the same locations where FPS-16s are situated, provide drone control site operators with a radar view of target position and heading.

Preventing radio interference with the channels used for data telemetry, and drone guidance over so large an area is a challenging problem. Frequency Monitoring Interference Control (FMIC) stations are located at key sites along the Florida gulf coast. Additionally, Convair T-29s, outfitted with receivers and direction finders capable of pinpointing interfering radio signal sources, patrol the range prior to and during tests.

A similarly equipped truck, known as the "electronic paddy wagon," is used to track down interfering signals on the Eglin complex, which itself has many sources of potential RF interference.

R&D Program

A modest in-house research and development program is under way at APGC, in addition to its traditional role.

A representative list of such programs includes: study of effect of impact at hypervelocities, advanced weapon trajectory studies, directed-energy weapons for ICBM defense, advanced target systems, aerodynamic flow effects at extreme conditions and chemical energy sources.

Avionics Directorate Faces Shift In Applied Research Responsibility

Wright-Patterson AFB, Ohio—The Avionics Directorate, one of four in ASD's Directorate of Technology, is responsible for applied research in five of the AFSC's 28 Technical Area Manager (TAM) functions. These are:

- **Navigation & Guidance** (730D).
- **Vehicle Defense** (730H).
- **Advanced Weapons** (740A).
- **Electromagnetic Warfare** (760D).
- **Reconnaissance** (760F).

Effective October 1, the Avionics Directorate will undergo an internal reorganization in which responsibilities will be shifted between laboratories to better balance the work load and prevent duplication of effort.

For Fiscal 1962, the Avionics Directorate expects to obtain about $60 million in Air Force funds for sponsoring applied research programs. This is about 5% less than last year, according to Col. T. J. Cummins, directorate chief.

In an effort to equalize the work loads of the four laboratories within this division, electronic warfare (airborne electronic countermeasures) has been shifted from the Navigation & Guidance Laboratory to the new Electromagnetic Warfare & Communications Laboratory, formerly the Communications Laboratory.

Similarly, responsibility for applied research in ferret propagation and antennas, formerly assigned to the Reconnaissance Laboratory, will become a function of the new Electromagnetic Warfare & Communications Laboratory.

The new organization will be:

- **Navigation & Guidance Laboratory,** under Col. D. K. Dean. Robert J. Doran is technical director. The Laboratory contains three branches: Electromagnetic Guidance, Inertial Guidance and Advanced Weapons Techniques.
- **Electromagnetic Warfare & Communications Laboratory,** under Lt. Col. Robert A. McDaris. Technical Director is Ronald G. Stimmel. The laboratory contains three branches: Electromagnetic Countermeasures, Electromagnetic Environment and Communications.
- **Reconnaissance Laboratory,** headed by Col. R. K. Rhodarmer, with Edward A. Woodford as technical director. There are two branches in this laboratory: Photographic and Optronics.
- **Electronic Technology Laboratory,** under Lt. Col. L. O. Carroll. H. V. Noble is technical director. Unchanged from the previous organization, this laboratory contains four branches: Molecular Electronics, Bionics & Computers, Thermionics and Advanced Techniques.

Prior to the reorganization, the Navigation & Guidance Laboratory was responsible for programs which amounted to about one-half of the entire Avionics Directorate budget, while the Communications Laboratory programs amounted to only about 10% of the budget total. Under the new organization, the funding is expected to be divided roughly equally among the four laboratories, according to Col. Cummins.

There were equally important technical reasons for the reassignments. The former assignments were based more on the end use of the techniques, where, for example, ferret work was viewed as part of the reconnaissance function. The new alignment is based more on grouping together similar techniques and in this respect ferret propagation and antennas, and airborne ECM, have much in common with ap-

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Besides being very lightweight and small, radio guidance equipment aboard the missiles is also simple and reliable—consisting of two transponders and a decoder. The transponders are really little more than two-way radios that handle coded messages giving precise position and velocity readings.

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plied research in communications.

Another recent clarification of work areas has occurred in the field of infrared. The Reconnaissance Laboratory has been given responsibility for all infrared detector and subsystem techniques work at wavelengths shorter than 300 microns, while responsibility for infrared work above 300 microns will be assigned to the Navigation & Guidance Laboratory. The one exception to this division is in the field of optical radar which is assigned to the Reconnaissance Laboratory.

Work in basic materials for application to infrared detectors remains in the Electronic Technology Laboratory.

Another recent change in assigned areas of responsibility is in the field of digital computing techniques. All basic state-of-the-art work will be centered in the Electronic Technology Laboratory whose programs in molecular electronics and bionics are expected to provide cornerstones for basic advances in computing techniques.

Application of new computer techniques to feasibility breadboard equipment as a prelude to possible application to a weapon system will remain the responsibility of the Reconnaissance and the Navigation & Guidance Laboratories.

Because of the explosive nature of avionics technology, the Avionics Directorate, as sponsor of applied research in many important areas, receives many unsolicited proposals from industry. The number of such unsolicited proposals in the fields of bionics and molectronics has reached the point where the Electronic Technology Laboratory is urging companies to first come in for informal discussions of new ideas before taking the time and spending the money required for a proposal. If the proposed investigation is an area of interest, and not already funded, ETL will then encourage the company to make its unsolicited proposal.

Present plans call for the Electronic Technology Laboratory to spend about $10 million in Fiscal 1962 in support of industry programs in molecular electronics, Noble indicates. But if several potential promising developments prove out, this figure might be increased by several hundred percent.

The laboratory now has about 10 modest-size contracts for work in the bionics field, most of which probably will be continued during the coming year. Noble concedes that one of the laboratory's problems is to find people with the unusual combination of scientific disciplines suitable for selecting and following programs in bionics.

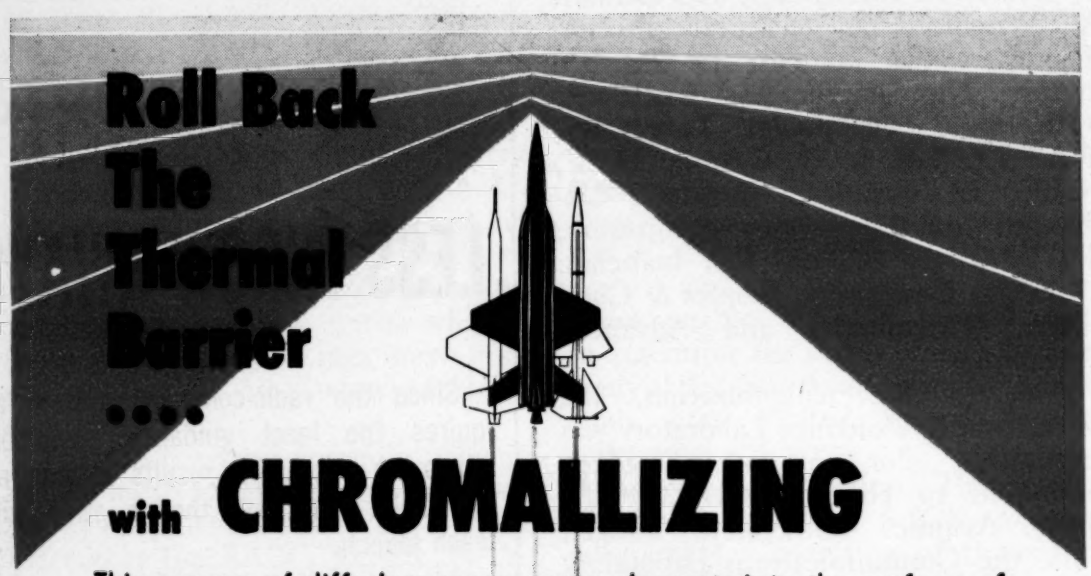
Noble says that ETL tries to use its modest funds to spark industry interest in areas where the immediate economic pay-off otherwise would not be sufficient to attract effort, withdrawing funding from these areas where industry can finance applied research itself. One such area, which ETL no longer funds, is transistors where natural competitive forces spur industry funding for development of new devices.

One study program in the field of electron tubes currently being sponsored by ETL is aimed at a traveling wave tube which could serve as a complete radio receiver with an audio/video output.

The Avionics Directorate's programs are intended to serve all four of AFSC's major divisions, according to Raymond Nordlund, technical director. Only about 25% of the programs sponsored are in direct support of the Aeronautical Systems Division here, he estimates.

Recently the directorate has taken over some of the applied research programs, such as advanced inertial guidance techniques, which formerly had been sponsored by the Ballistic Systems Division, where they are not intended for use on a specific weapon system.

Col. Cummins expects that during the coming year there will be increased emphasis on applied research which is applicable to limited warfare situations.



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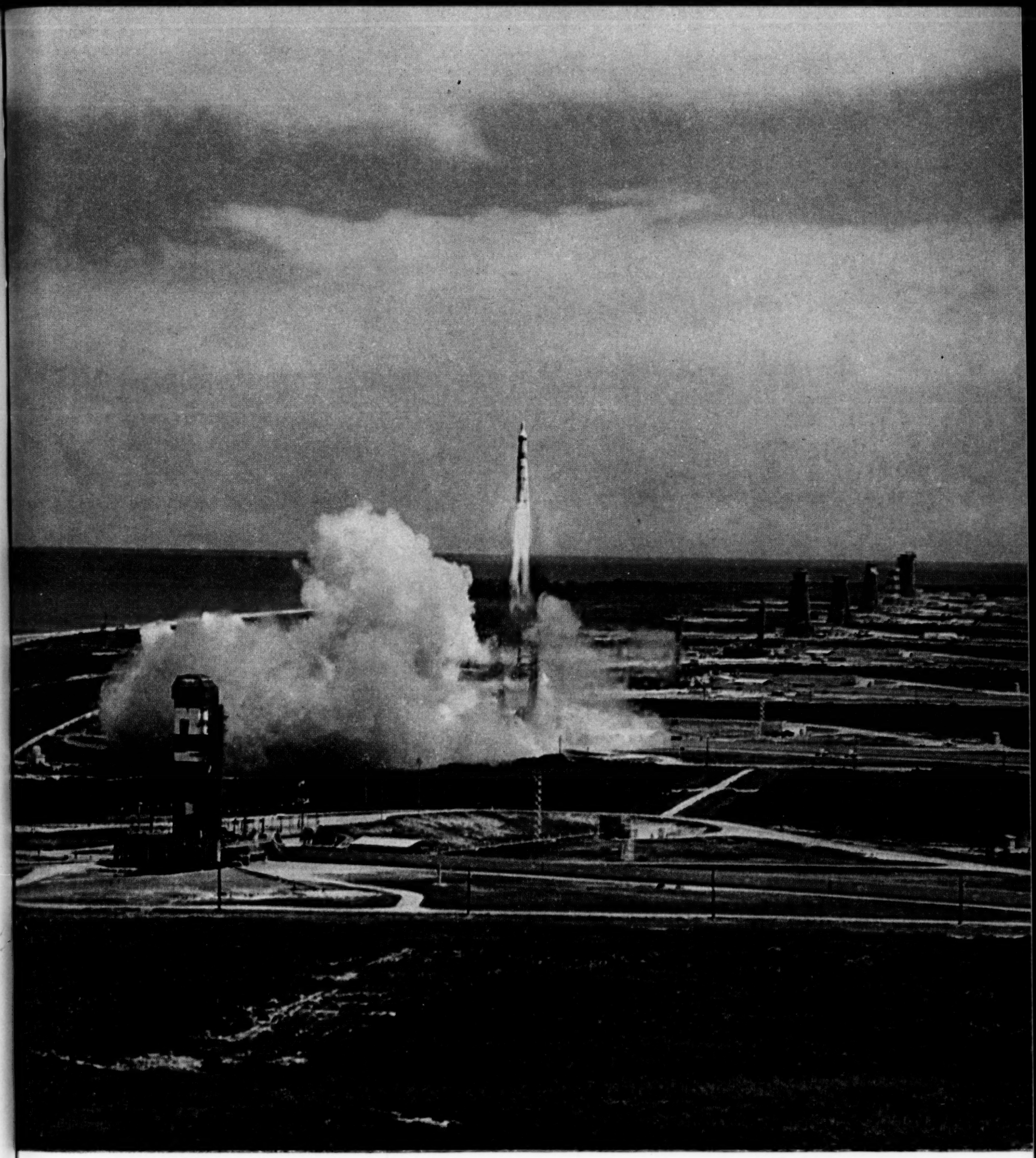

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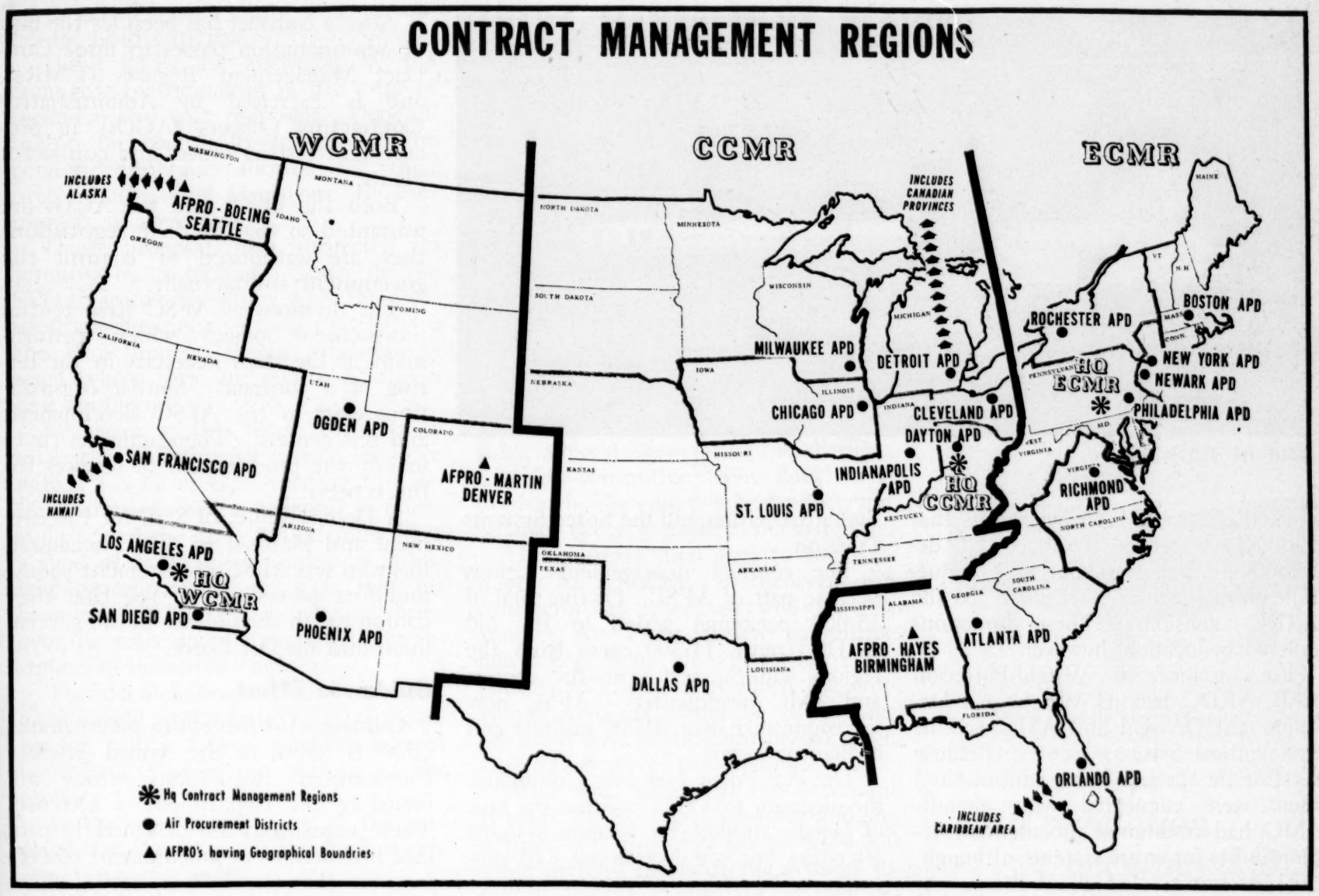


Systems Command Has New Buying Power

More than $7 billion is to be spent in Fiscal 1962; cost rules tightening as fixed-fee contracts rise.

As a single integrated procurement organization, the Air Force Systems Command deals with more than 6,000 prime contractors and administers more than 37,000 prime contracts.

Its contracts run the gamut from study efforts of future weapon systems by scientist and engineer-staffed organizations through the whole cycle of research, development, test, evaluation and production by a wide variety of businesses.

For the Fiscal Year 1962 which runs until next July 1, AFSC will have the responsibility of funneling more than $7 billion in new obligational authority into scientific and industry channels.

The procurement machinery has had to keep pace with technological progress. Not only must it do its job efficiently to place weapon systems into the hands of the users in the quickest time possible, but it must maintain close surveillance of all contracts to see that the U.S. gets the most for its dollar.

This surveillance is applied in depth as well to a wide representation of U.S. business because the 200 prime contractors who hold over 90% of the contract dollars spend about two-thirds outside their plants for materials, supplies or subcontracts.

Of all the procurements of AFSC, only about 20% are of the fixed-price variety in terms of dollars spent. In the 10 years since 1951 the percentage of contracts of the cost-plus-fixed-fee type for the whole department of defense has increased from 13% to 41%. Air Force experience follows this closely with a present figure of 42%. The remaining percentage is composed mainly of variations of fixed-price types.

With such a large number of cost type contracts under its management the obligation of the Air Force for close surveillance to avoid overspending and reprograming has increased. Contractors doing business with the Air Force can expect new and more stringent scrutiny of costs. There will be tighter, tougher rules concerning allowability. A sense of urgency will no longer be used as an excuse for uneconomical spending.

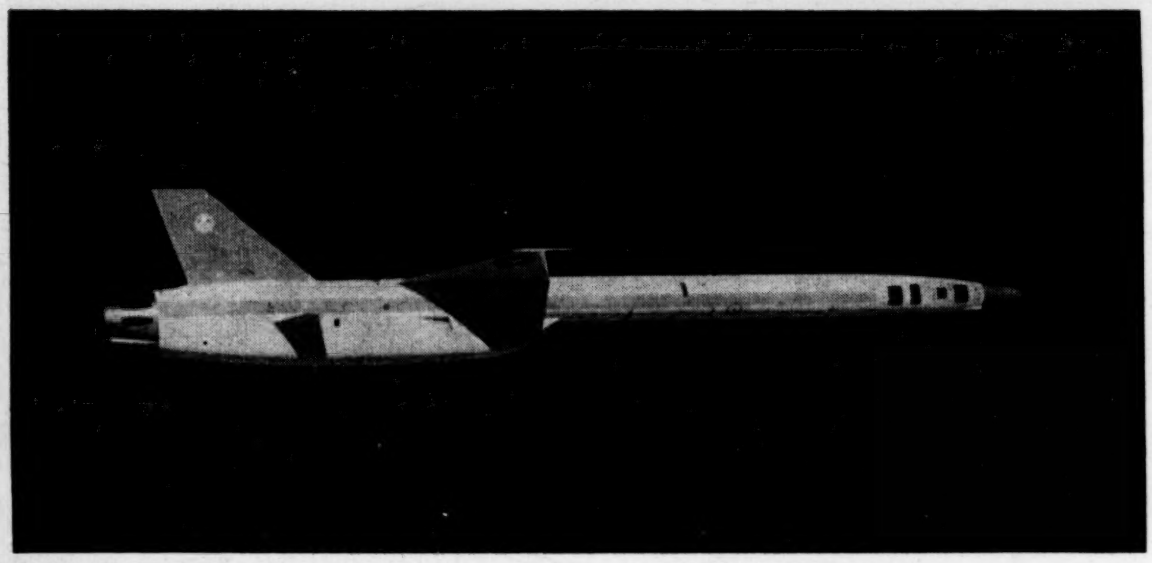
To adjust to technological progress changes have had to be made. The government no longer furnishes parts to be assembled into a simple end product. The prime contractor does most of the subcontracting, and his actions must be closely monitored by a single manager.

Two concepts have influenced changes in procurement more than anything else. One is the idea of systems, where in one single package the weapon, its means of delivery, its control, its guidance and its logistic support and related items are lumped together as a total program. The other is concurrency, where production of the weapon system is begun during the development phase to save time.

These concepts made former procurement processes obsolete. It became necessary to gear them to a faster pace.

Under the divided responsibilities for the acquisition phase of weapon systems that were in effect prior to last July 1, the predecessor Air Research and Development Command and the Air Materiel Command split their duties in the letting and administration of contracts.

ARDC only procured basic and some



Q-4B IN FLIGHT

applied research. But it was AMC that handled, in general, contracts for development, test, evaluation and production through centers that paralleled the ARDC divisions. These functions differed by location, however.

For instance, at Wright-Patterson AFB, ARDC had its Wright Air Development Division and AMC had its Aeronautical Systems Center. Because most of the systems being administered there were connected with aircraft, AMC had traditional procurement responsibility for entire systems, although, this was not true of all of them. At Hanscom AFB, Mass., AMC, through its Electronics Systems Center, procured everything after the research stage and ARDC's Command and Control Development Division procured basic and applied research.

At Inglewood, Calif., ARDC's Ballistic Missile Division procured basic and some applied research and AMC's Ballistic Missile Center took it from there.

The gray area for the shift of responsibility from AMC to ARDC was hard to define, since concurrency forced production along with development in many weapon systems.

Contract managers at contractor plants actually worked on projects for both ARDC, AMC and other government agencies but were directly responsible to AMC which had management cognizance through its Contract Management Regions.

Combined Procurement

Creation of AFSC specifically put all procurement of weapon systems under one roof through the complete development cycle to delivery of combat-ready systems to the operational commands. At Wright-Patterson AFB, WADD and ASC combined to form the Aeronautical Systems Division of AFSC. At Hanscom AFB, CCDD and ESC became the Electronics Systems Division. At Inglewood BMD and BMC became the Deputy AFSC Commander of Aerospace Systems with two subordinate divisions, the Ballistic Systems Division and the Space Systems Division.

The contract management regions became part of AFSC. Of the total of 15,000 personnel added to the old ARDC count, 11,500 came from the regions and the rest from the centers and AMC headquarters. AFSC now has cognizance over 60,000 military and civilian personnel.

The Air Force Logistics Command, the successor to AMC, now has the task of logistic support for weapon systems after they become operational. Its procurement functions cover common, or off-the-shelf items and re-orders of units or parts of weapon systems. The initial spare parts procurement belongs to AFSC, but re-orders are the responsibility of AFLC.

Focal Point

Focal point of the systems command effort is the Systems Program Director (SPD) whose Systems Program Office (SPO) has complete control over the acquisition of a weapon system after a determination has been made to develop and produce it.

Formerly these teams were called Weapon System Program Offices. The Director of a WSPO would report to ARDC from inception of the program until it was determined that the program was ready for production and then he would be ordered to report to AMC.

There are SPOs in all of the divisions. Their projects cover the range of aeronautical, electronics, missile and space systems.

Every element necessary for the orderly accomplishment of the task is represented in the SPO. There are representatives from the user operational commands, the Air Force Logistics Command which supports the weapon system after it becomes operational, and other interested agencies.

A key member of the SPO is the Procuring Contract Officer (PCO). He is the focal point for contact with industry to launch a project once a determination has been made to go ahead with it.

After a contract has been let the task of administration passes to three Contract Management Regions (CMRs), and is exercised by Administrative Contracting Officers (ACOs) in procurement district offices and contractor plants.

Both the PCOs and the ACOs are warranted so that in their negotiations they are authorized to commit the government contractually.

The divisions of AFSC have central procurement offices which perform many of the steps necessary in the letting of a contract. Similar organizations exist in the AFSC development and test centers. Their activities cover mainly the procurement of services for the centers.

A Deputy Chief of Staff for Procurement and Materiel in AFSC headquarters who sets AFSC procurement policy, monitors procedures to see that they conform with the policies of the government and the Air Force.

Guidance Effort

Guidance for the entire procurement effort is found in the Armed Services Procurement Regulations which are issued by the Department of Defense. These regulations are designed to provide instructions to procurement officers in order that the defense buying effort is reasonably uniform. The ASPRs are industry's assurance that there will not be a separate set of rules for each service.

There is a complex sequence of events which leads to the final signing of a contract. The description that follows is not static and can be varied in many ways. There are many fine points in negotiations that are not covered by the ASPRs or other regulations.

This is where human judgment enters the picture. There can be no complete set of rules written to cover every contingency of negotiating for the development and production of weapon systems. General prudential rules, based on law, must suffice, with the human element taking over after that.

After it has been determined that the Air Force wants to go ahead with the procurement of a system, the requirements of the work to be done must be balanced against the capabilities of a list of qualified potential contractors.

From this list a number of companies will be sent requests for proposals (RFPs) on the project. The RFP contains the specifications covering the work to be done. These specifications are written in some detail, but there is room left for ingenuity on the part of a company submitting a proposal.

In some instances, the skills and production abilities required for a project may result in only one qualified contractor being found. It is under such circumstances that the greatest care must

be exercised by the contracting personnel to avoid criticism.

These RFPs are answered by the companies participating in the form of technical and cost proposals. Depending on the complexity and size of the project, the time allowed for their preparation varies from one to four months, or even longer.

These proposals are subjected to scrutiny by a technical team in the SPO to see whether they meet the technical specifications. Those that survive this step then go to the procurement team where they are reviewed from a cost standpoint.

Key man in this team is the price analyst, usually a civil service employe with a GS-12 or GS-13 rating. In determining whether a proposal is financially sound the price analyst must have a fund of working knowledge in industrial procedures. If he feels that his knowledge is limited in any field, however, he calls upon a specialist, for instance an industrial engineer.

The detailed financial analysis bears great weight in the final choice of a contractor. Other factors, such as current work load, also have a bearing on the choice.

In the meantime copies of the proposals have gone to Air Force plant representatives for review.

When a final choice has been made the ASPRs require that a pre-award survey, or Facility Capability Report, be made. The survey team is composed of personnel from a procurement district operating under a contract management region. The resulting report will reflect an affirmative, negative or qualified position on the company's capabilities in management, production processes, manpower, tools and facilities.

The commander of the division is then given a pre-negotiation briefing. Adjustments are made according to his wishes.

Negotiations Launched

At this point the first contact between the PCO and his team and the contractor team is made in the form of a fact-finding conference. Fact finding is not per se negotiation, but there may be some nevertheless.

If there is agreement at this conference, negotiation will begin. If not, more time for study is allotted.

When final negotiations begin, the resident auditor general, the price analyst and the plant representative sit as members of the Air Force team. Only one person talks for the Air Force. Depending upon several circumstances this may be the PCO or some higher ranking officer or civilian. Importance of the contract and personality are considered in the choice of the spokesman. In the give and take that marks negotiations, it is possible that two individuals may not consult amicably. Changes are made as needed.

During these negotiations every facet of the work to be done is discussed. Such items as the number of employes to support the project, quality control and schedules are agreed on.

If this meeting results in agreement, the price analyst writes a memorandum which the SPO approves and sends to the contract writers.

The contract writers are a highly specialized group which has to exercise care in the wording of a contract because of its legal nature. When completed, the document is reviewed by the judge advocate general of the division. A review committee, whose function is to give the document a final policy and accuracy check, completes the first cycle.

The contract then goes to the contractor for signature. In the event the contractor has other suggested changes, another Air Force review committee may accept them. If not, further negotiations will be held in which the individuals involved would be at the vice president level in the company and high ranking officers of the division.

After final agreement the document is ready for Air Force approval and signature. For amounts up to $350,000 some division chiefs of the systems divisions hold authority for written approval. The division commanders have authority to approve contracts up to $5 million.

If the amount is higher than $5 million, the contract must go to AFSC headquarters for approval and signature.

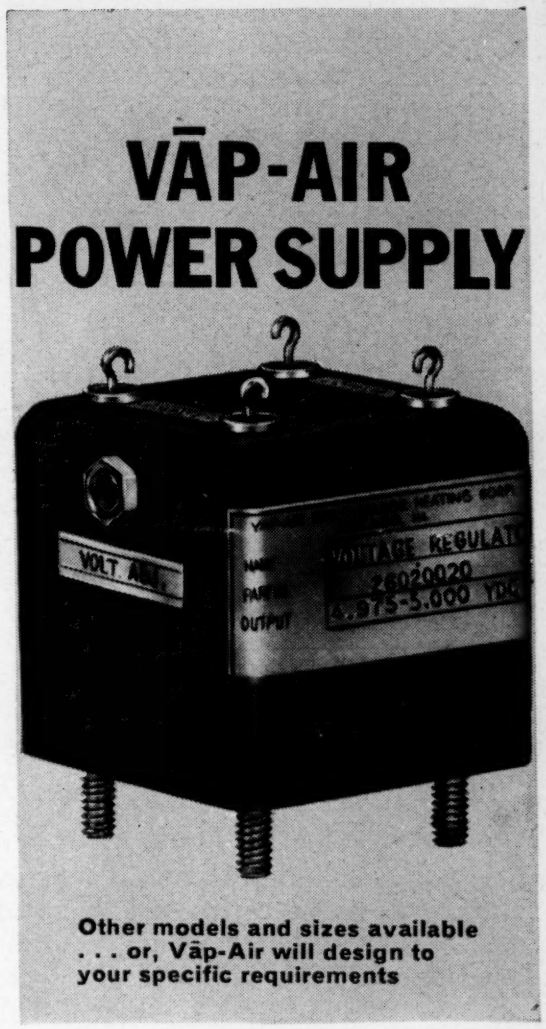
In the case of contract awards where larger sums will be involved over a number of years the recommendations are taken to AFSC headquarters and then to Air Force headquarters staff for review.

The AFSC Deputy Chief of Staff for Procurement and Materiel monitors the negotiations for the larger contracts. His organization has a nucleus of highly experienced negotiators who can help the division personnel in dealing with some of the more difficult contract conferences.

After a contract has been let another phase of close relationship with industry begins in the form of Air Force management of the contract during its lifetime.

AFSC has three Contract Management Regions (CMRs) to administer the billions of dollars of contracts in thousands of plants. These regions, formerly under the Air Materiel Command, managed production contracts. They were not limited to this phase of the acquisition cycle, however; they also administered development and research types of contracts for the Air Research and Development Command.

With the formation of AFSC, the



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BRIEF SPECIFICATIONS

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Output Voltage..... 4.975 to 5 VDC
(under all conditions of line load and temperature variations)
Load..... 0-100 MA
Output Ripple.....30 MV peak to peak under input transient conditions
Ambient Temp. Range.....−65°F. to 185°F.
Altitude.....100,000 feet
Size.....1½" x 1½" x 1½"
Weight.....5 ounces
Environmental.....MIL-E-5272C

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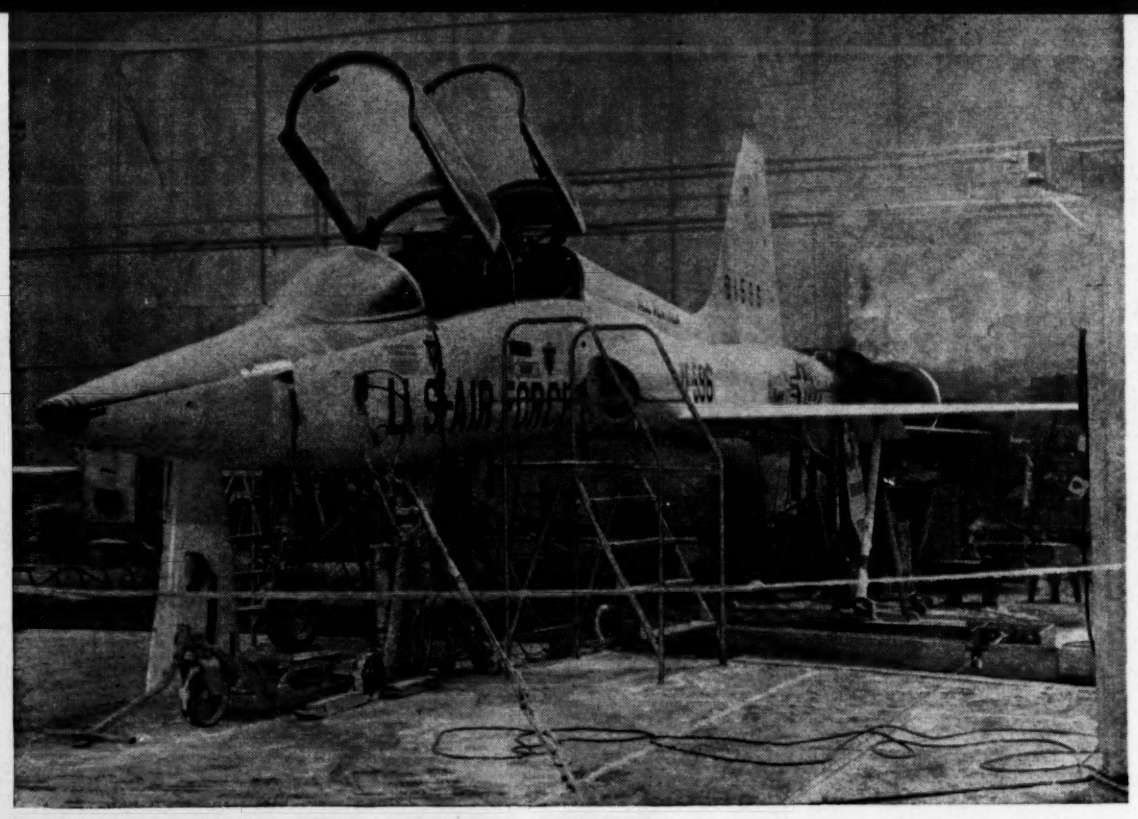

T-38 UNDERGOING COLD WEATHER TESTING

CMRs now form a single link between AFSC and industry for a weapon system until it becomes operational. The CMRs also represent the Logistics Command and other government agencies.

Regions Described

The Eastern Contract Management Region is located at Olmsted AFB, near Harrisburg, Pa. It covers 19 eastern states and the Caribbean area. The commander is Col. H. J. Mattia.

Largest of the regions is the Central Contract Management Region commanded by Col. D. W. Graham, with headquarters at Wright-Patterson AFB. It covers 18 states.

Commanding the Western Contract Management Region is Brig. Gen. G. F. Keeling whose headquarters are at the Air Force Station, Mira Loma, Calif. His area covers 13 states, including Alaska and Hawaii.

The CMRs are service organizations whose success or failure will be judged by how well they provide service to the buyer and the seller. The quality of the final product is also dependent on their effort.

Subordinate to the CMRs are Air Procurement Districts (APDs) whose offices are scattered nationwide near the centers of procurement activity, and Air Force Plant Representatives (AFPRs) who are usually located in the plant of a major contractor. There are 21 APDs and 24 AFPRs.

Chiefs of the APDs and AFPRs and their staffs are Air Force technical administrative and contracting experts. They are given sufficient authority and responsibility to get their jobs done.

Technological progress caused the formation of the three regions. Management of the buying function of the Air Force was subjected to heavy criticism in 1959 by the General Accounting Office, Congress and the USAF Inspector General. As a result of a survey and recommended organizational changes the three regions were formed from what had been part of eight decentralized Air Materiel Area Directorates of Procurement. These directorates had suffered from lack of responsiveness to central control. By reducing the number of staffs, talent was concentrated and coordination was improved.

The reorganization also recognized that, with the need to shorten lead times and concentrate on the systems concept, the prime contractor had a new relationship with the government because he was given the responsibility for developing a better capability of integrating subsystems.

The control of expenditures of more than $7 billion annually for AFSC and $2 billion for AFLC present a challenge to the CMRs, especially when it is realized that 42% of the dollars go into cost-plus-fixed-fee type contracts. These require close surveillance in order to protect the government.

Administrative Delegations

To cover contract management, a system of administrative delegations is necessary. As described before, a contract originates with the Procurement Contracting Officer in the SPO, or it may originate in an Air Materiel Area, National Aeronautics and Space Administration, the Navy or other agency. From there the delegation flows to the Administrative Contracting Officer in the plant holding the basic or prime contract.

In turn, the prime ACO redelegates as necessary to cover subcontract or out-of-plant work. An example of this would be the delegation by the prime ACO at the General Dynamics/Fort Worth plant which produces the B-58 bombers, of work on the tail turret for the aircraft to the secondary ACO at a subcontractor plant.

The advent of ballistic missiles imposed the difficulties of distance on contract management. For work done far from plants at missile sites it was necessary to establish field offices at test and operational facilities.

In the flow of delegations discussed above it must be noted that the CMR is bypassed. He is cognizant of what is being done, but time is saved by going direct from the PCO to the plant ACO.

Effective communications between organization levels is mandatory for the proper flow of work to be maintained. These communications are gathered at a central point in the SPO where a production tracking system is operated to control every component of a weapon system. Some of the Air Force weapon systems are controlled through the PERT tracking device which was expanded and refined by the Navy's Polaris project office.

Information for the tracking system originates with the in-plant member of the team. His progress reports are integrated into the whole production maze. If his components are being produced ahead of schedule he can be advised to reduce the effort and place the emphasis elsewhere. If the work is lagging, he can order a speedup and overtime work.

Contractor operations are closely scrutinized to make certain that they have methods of operation that will allow them to meet their responsibilities. Scattered throughout the CMR organization are 60 purchase method analysts whose full-time duties consist of heading the teams that review in great detail how the contractor's purchasing operations function, principally in reference to subcontractor operations.

Most of the large contractors have been surveyed by these teams. The results of their surveys are reviewed by a CMR panel after which the findings are presented to the contractor. In this way the Air Force assures itself that company management conforms to its standards.

Some of the specific items surveyed by the teams include purchase methods, cost accounting, quality control, manpower utilization and overtime control, production master planning and scheduling, value engineering and reliability programs, time standards and efficiency measurement, industrial security control, subcontractor selection and price and cost estimating systems for developing proposals.

After such a survey there are continuing checks and samplings to assure that there has been no deterioration.

The key members of the contract administration team are warranted contracting officers, purchase methods analysts industrial property specialists. Some of their more important functions are:

• **Determination** as to whether a contractor's accrued costs will be allowed in the price paid by the government on reimbursable contracts in accordance with the ASPR's. Close coordination with the resident auditor-general is maintained to assure that submitted costs are subject to continuous audit review.

• **Analysis** of the elements of a contractor's proposal with the help of the industrial engineer and other team members who work with the price analyst, as already described.

• **"Watch-dogging"** by the property administrator of materials, supplies and real property belonging to the government.

• **Termination of contracts** by the government for its convenience. Settlements are made by the PCO in accordance with actions taken by the field administrator.

• **Quality control inspection.** No longer does the government inspector carry a plug gauge to spot check items on the production line. His equipment is complex and specialized. In a few instances he must pass every item that is produced.

• **Comptroller services.** Accounting procedures have grown more complex along with complexity of weapon systems. Punch card-computer systems are now standard for accounting, disbursing and related data collection and processing.

• **Transportation and packaging.** These two fields are related because packaging must be fitted to the type of transportation available. An example of this is the highly specialized cradling and pressurization system needed for transportation of Atlas missiles by truck or aircraft.

Program Director

As the single coordinator in the acquisition of a weapon system, the System Program Director has the responsibility of guiding the activities of a wide variety of personnel—his own, the contractor's, those of other commands and those representing agencies interested in the project.

An example of how widespread this representation can be is the structure of the System Program Office for the GAM-87A Skybolt air-to-ground ballistic missile which is designed to be carried by the B-52 jet bomber as a standoff weapon. This program involves another country, Great Britain, which intends to carry the Skybolt with its Vulcan bombers.

Thus the Skybolt SPO has representation from the user command; the Strategic Air Command; the Training Command where personnel will be trained in maintenance and operation of the systems; the Logistics Command, which will be responsible for operational logistic support; the contract management region; Royal Air Force; England's A. V. Roe Co.; Douglas Aircraft Co., the prime contractor; Nortronics Division of Northrop Corp., Aerojet General and General Electric Co., the principal subcontractors.

Commitment Powers

In most instances the representatives are authorized to commit their command or company on some matters. If they cannot make a commitment, they have direct access to the decision making machinery located with their superiors.

Daily conferences are held in the SPO to make engineering decisions. Differing ideas are compromised and the results evaluated to determine whether they meet the system requirements.

The SPO as a coordinating organization came into being as the result of a series of Air Force Regulations bearing the prefix 375. Certain functions are spelled out, one of which is the formal working elements within the SPO. There is an executive council which reviews and passes on decisions made by subordinate working elements, and the Program Manager Conference whose working members are the Air Force Manager and the contractors' managers, where the basic engineering decisions originate.

An effort such as the Skybolt needs an analysis of the technical problems to be solved. Accomplishing this is a continuing task throughout the life of the program. It is necessary in order to produce specifications for the work to be done in the future. Each test of a component or major subsystem must be analyzed and the result must be integrated into the whole data library.

There are three categories of data. One is the type that comes to the SPO for approval. The key document is the weapon system specification which defines operational expectations, supply systems and personnel skill requirements. It must tell the contractor early enough in the program what is to be expected and how he is going to demonstrate the system's accuracy, reliability, maintainability and performance. Personnel skill levels and training are considered a personnel subsystem.

Other Data

Other data comes in to serve as a checkpoint, for comment or coordination, while some information is retained at a contractor's plant. The net result is that the contractor is told what to do

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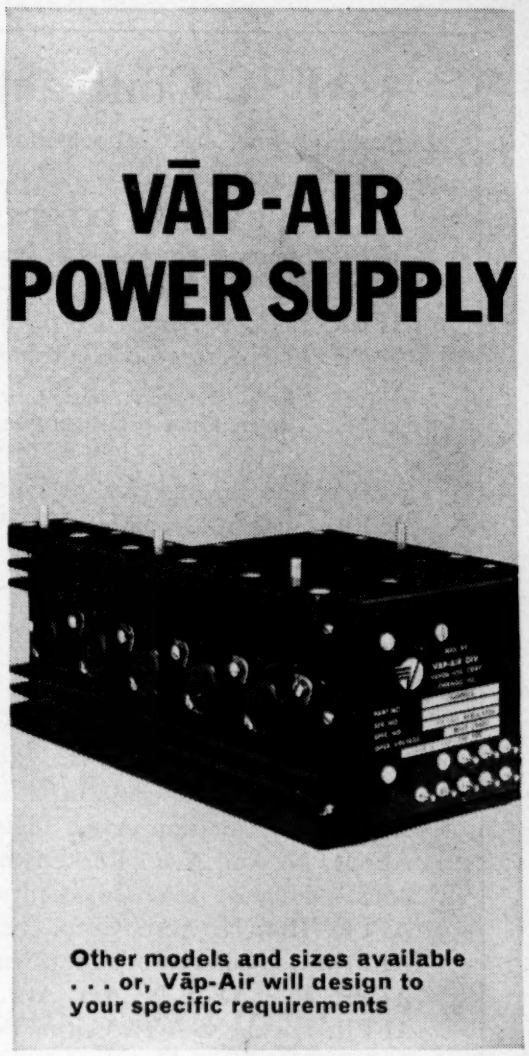

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BRIEF SPECIFICATIONS

Input Voltage.....25 to 31 VDC
Output Voltage..5 VDC ±5 MV, 20 to 500 MA
150 VDC ±1%, 140 MA
250 VDC ±3%, 170 MA
Ambient Temperature Range.....0°C to 71°C.
Size.....3¼" X 7½" X 3½"
Weight.....3.25 lbs.
Environmental.....MIL-E-5272C

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AFSC Contract Management Regions

Indicated below, by contract management regions, is a current list of Air Force plant representatives:

EASTERN CONTRACT MANAGEMENT REGION

AFPR, Sperry Gyro Co., LI, N. Y.—Col. Douglas L. Rundquist
AFPR, GE Co., Syracuse, NY—Lt. Col. Willie E. Livesay
AFPR, Lockheed Acft. Corp., Marietta, Ga.—Lt. Col. William A. Harmon
AFPR, The Martin Co., Baltimore, Md.—Lt. Col. G. K. O'Neil
AFPR, Republic Avn., LI, N. Y.—Lt. Col. K. E. Beary
AFPR, Hayes Corp., Birmingham, Ala.—Maj. A. Parsons

CENTRAL CONTRACT MANAGEMENT REGION

AFPR, The Boeing Co., Wichita, Kan.—Col. Warner E. Newby
AFPR, General Dynamics, Ft. Worth, Tex.—Col. Leonard R. Hall
*** AFPR, Beech Acft. Co., Wichita, Kan.—Capt. Jack W. Setliff**
AFPR, Douglas Acft. Co., Tulsa, Okla.—Lt. Col. Zack Gray
AFPR, GE Co., Cincinnati, Ohio—Lt. Col. Oliver W. DeGruchy, Jr.

WESTERN CONTRACT MANAGEMENT REGION

AFPR, The Martin Co., Denver, Colo.—Col. Bobbie J. Cavnar
AFPR, The Boeing Co., Seattle, Wash.—Col. William A. Clark
AFPR, Aerojet-Gen. Corp., Nimbus, Calif.—Col. William K. Ashby
AFPR, Lockheed Acft. Corp., Sunnyvale, Calif.—Col. James H. Voyles, Jr.
AFPR, N. American Avn., Inglewood, Calif.—Col. Sherman E. Ellis
AFPR, N. Am. Avn., Rocketdyne Div., Canoga Pk., Calif.—Col. John H. Strand
AFPR, Hughes Acft. Co., Culver City, Calif.—Col. James T. Mc Kee
AFPR, Douglas Acft. Corp., Santa Monica, Calif.—Col. Edward H. Robertson
AFPR, Convair/Astronautics, San Diego, Calif.—Col. Harvey E. Moose, Jr.
AFPR, B-70 SPO, N. Am. Avn., Inglewood, Calif.—Col. Max W. Boyer
AFPR, Lockheed Acft. Corp., Burbank, Calif.—Lt. Col. J. M. Kirkland
AFPR, Northrop, Hawthorne, Calif.—Maj. C. W. Clark

*** Merged with AFPR Boeing Co., Wichita, Kan. 1 Sep. 61**

and in some cases how to do it.

Program control requires a mass of reports. The principal tool used in control of the manufacture of the Skybolt is the PERT tracking system which is applied to every system component and part to find whether schedules are being met or not. Desired milestones are applied to PERT. Then the production of every part is compared with these milestones.

Both positive and negative slack can be spotted with PERT. Negative slack, or the indication that a part is behind schedule can result in orders for increase in work force or other measures.

Positive slack indicates that the component is ahead of schedule. This is also undesirable, for the labor surplus can be applied to other schedules in need of greater effort.

PERT status reports are produced biweekly for the total program. These reports are signals to managers concerned to take action. Tracking is performed for many events, such as the first guided flight and air launching.

Program control does not simply consist of tracking nuts and bolts, however. The SPD has to keep track of funding, prepare and monitor financial plans, and integrate reports concerning the program. He is in the business of matching dollars to time.

In less formal areas he must be able to adjust assignments to place personnel in key positions whose personalities do not clash. He must be ready for policy changes from higher echelons. In the Skybolt program, for instance, there were fluctuations in priority last November and December during high level debate on the necessity of the program which had international repercussions.

Contract types can be divided into two general pricing classifications, fixed price type contracts and cost-reimbursement type contracts.

The fixed-price contract is the traditional instrument for competitive business in the United States. Whether the product be hardware, services or effort, the customer thinks only of price. He need not be concerned with production costs. This type of contract is usually the result of competitive bidding. It is applied by the military services to the purchase of goods or services that lend themselves to relatively easy estimation of costs and positive descriptions. The product is either standard or simple in nature.

In estimating what the final cost will be in analyzing a fixed-price contract, the Air Force does not "allow" or "disallow" costs or profit, but it does "allow" a price. Profit, then, becomes that part of a price which the contractor does not spend on costs. All costs come out of the contractor's price.

In another type of contract – cost-reimbursement – government pays the costs incurred in doing the work called for by the contract. At stated intervals, usually every 10 days to two weeks, the contractor submits a list of costs for labor, material and services and in turn receives a check for cost recovery.

The fixed-price contracts fall roughly into another two groups. Contracts awarded as a result of sealed bidding all fall into this category and to a considerable extent the negotiated procurements fit this pattern.

Price-redetermination type contracts fall into the first grouping. This means that the initial price agreed on is not firm and is subject to adjustment at some future time. Some of these contracts provide for pricing after knowledge has been gained on costs and production methods. Others provide for repricing at stated intervals. Some provisions make repricing retroactive and others place it in the future.

If a contract provides for one or a series of price redeterminations, it becomes a firm fixed-price contract after the final redetermination.

The second type of modified fixed-price type contract includes the incentive formula. Here there is a target price rather than a firm one.

The target, or hoped for price, is separated into a target cost and a separate target profit. After the contract is completed, the actual cost is compared with the target cost. By whatever amount the cost has varied from the target cost, the target profit likewise varies inversely. At the time this type of contract is negotiated the limits of target profit in terms of percentage are set. If these are exceeded adjustments are made, either for or against the contractor.

Fixed-price-incentive contracts are used by the Air Force in the production of aircraft, some kinds of missiles and some aircraft engines. Fixed-price contracts containing price redetermination clauses are used for procurement of aircraft engines, electronic subsystems and other procurements.

Cost-reimbursement type contracts, more popularly known as cost-plus-fixed-fee (CPFF) contain provisions that allow for payment of the contractors' allowable costs plus the payment of a profit in the form of a fixed fee.

This fee remains static and does not change with changes in actual costs from those that were estimated. The fee may change, however, if specifications in the work performed are altered.

Another common type contract is the cost-plus-incentive-fee (CPIF) which operates similarly to the fixed-price-incentive type contracts described above. In it the contractor's final fee is determined by a percentage sharing arrangement dependent on the relationship between the original estimate of cost and the actual cost.

Fees in both the CPFF and CPIF contracts are subject to maximum and

minimum limitations. Costs, however, have no such formal limitations placed on them but are subject to stringent control.

One variation in the procedures followed in requesting proposals from industry is the "Two Step Advertising" approach. Instead of combining technical and price proposals, REPs asking for only the technical approach are sent to industry. After their receipt they are reviewed. Those assessed as being marginal are sometimes returned with suggestions for their improvement. This device is used to provide a wider representation in the bidding list.

Price Proposals

All those manufacturers whose technical approaches are considered satisfactory are invited to submit price proposals. Since there are two distinct time consuming steps involved, this time-delay method is not popular in procurement of urgently needed weapon systems.

The time-and-material contract provides direct payment of a fixed hourly rate for direct labor used.

The contractor has the maximum profit incentive to keep his costs down in the fixed-price contract.

From the standpoint of the government, the fixed-price contract provides the maximum amount of price control, while the CPFF provides the maximum amount of profit control.

The ideal type of contract which protects the government, delivers the product wanted and gives the contractor a fair profit is the subject of continual discussion. At a forum held last spring by the National Security Industrial Association, Assistant Secretary of Defense for Installations and Logistics Thomas D. Morris proposed a type which would provide for a board of experts, who, after the completion of a contract, would determine the fee the contractor would receive. Other types of contracts were discussed, but the Department of Defense has not yet directed a change.

Source Availability

There are many factors which influence the type of contract the Air Force specifies. One is the availability of sources. If there is substantial competition from a wide bidders list and other factors allow it, the fixed-price contract is best. If only one source is available then the modified fixed-price or cost-type contracts would be used.

The character of the specifications has a direct bearing on the type of contract. A clear work statement makes a fixed-price contract possible. If they are not complete and subject to change the type of contract which provides flexibility through negotiation is used.

If the Air Force has wide cost experience in one particular kind of production the fixed-price vehicle is used. However, if a contract runs over a period of years, inflation or other conditions may cause financial difficulties for the contractor. He can be protected by use of a modified fixed-price contract.

When fixed-price contracting is not possible or desirable, the incentive type contract is used. The aim is to foster contractor's interest in reducing costs, yet protect him from risk if a program is subject to changes during the life of a contract.

A delicate balance must be maintained in determining types of contracts and managing them. Cost controls shouldn't be emphasized to the point that quality in design, reliability and efficient production suffer. Cost squeezes can degrade performance. Conversely, too much pressure can result in skyrocketing costs.

Four Categories

In accounting and providing material which will be used in the performance of contracts, the Air Force has established four categories. They are as follows:

- **Category I**—Contractor Furnished Equipment (CFE). Obtained by direct contract between the Air Force and the weapon system contractor.
- **Category II**—Associate Contractor. Obtained by contract between a subsystem or equipment manufacturer and the Air Force. It is manufactured according to the specifications furnished by the weapon system contractor, who will be the recipient of the equipment for inclusion in the weapon system to be produced.
- **Category III**—Government Furnished Aerospace Equipment. Obtained by contract between a subsystem or equipment manufacturer and the Air Force. It is manufactured according to specifications furnished or approved by the Air Force and goes to the weapon system contractor for inclusion in the weapon system.
- **Category IV**—Issue Items. Obtained by contract between a subsystem or equipment manufacturer and the Air Force using specifications furnished or approved by the Air Force for use by its commands.

AFSC is conducting a formal procurement improvement program. Close checks are being run on 16 areas of the procurement process. Every procurement activity has to report accomplishment or non-accomplishment in each area.

Areas covered include buying, competition, quality, reliability of costs, specifications, time reduction, reward or penalty according to performance, reduction of costs and streamlining of reports.

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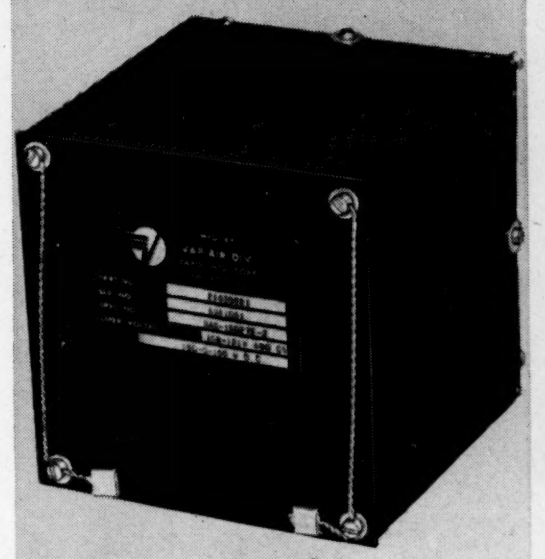

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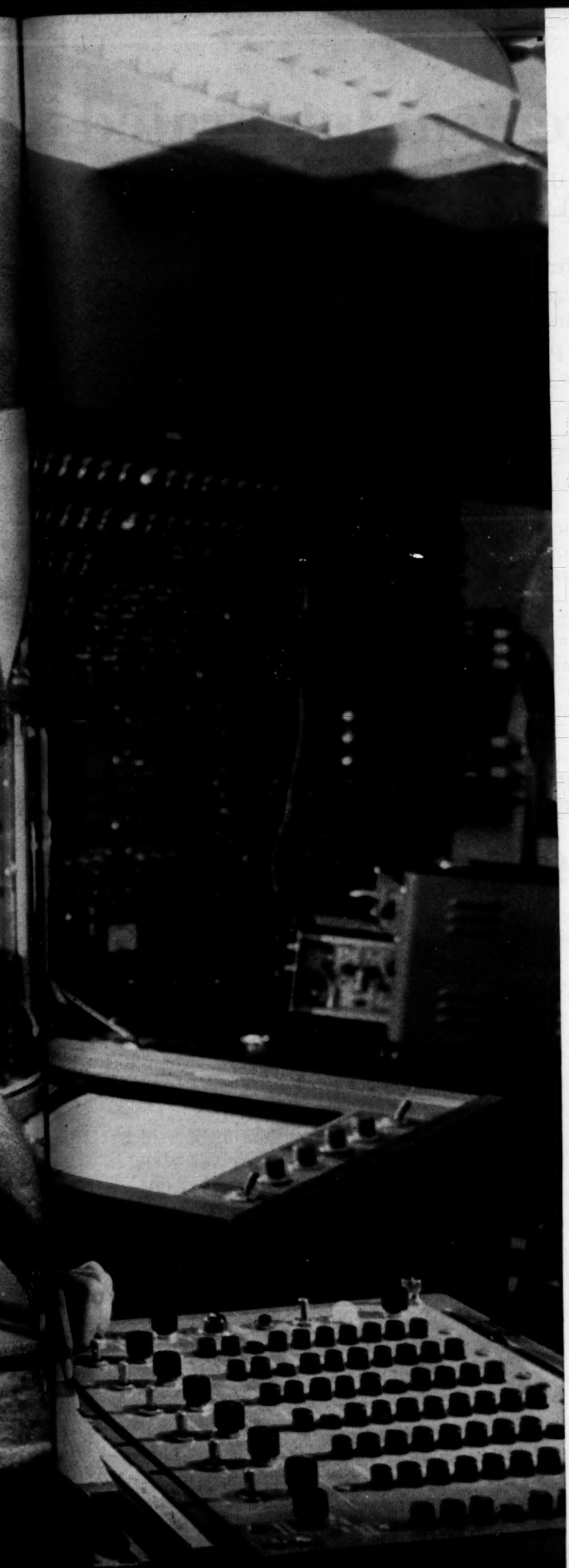

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Analog Computer Lab—Raytheon

Applied Research Management Integrated

Andrews AFB, Md.—Management of applied research within the Air Force Systems Command cuts across conventional organization charts in a concept new to the Air Force: Technical Area Management.

In its simplest terms, this concept gives one man in AFSC the responsibility for all Air Force applied research in one area of interest, regardless of where that research is being done. He assigns projects to appropriate divisions or centers for work; establishes a priority rating for each project; keeps each project leader informed on funding available, additional or urgent work over the original program, and changes in direction or priority of the research effort.

In addition, that man—called the Technical Area Manager (TAM for short)—is responsible for the dozens of status reports, management analyses, and other documentation without which an applied research program could not exist.

Assistance for TAM

He is assisted in this monumental task by two other types of scientists or engineers: the Technical Area Coordinator (TAC) and the Planning Objective Coordinator (POC). These three groups of individuals manage and monitor every bit of Air Force applied research in every division or center for every approved objective.

One or more of these individuals or groups will show on almost every formal organization chart within AFSC. A graphic pattern of applied research management probably could be drawn, but it would resemble a roll of fencing.

The best way to understand the operation and interaction of these three important managerial groups is through a description of how they evolved.

Applied research in the Air Force is of two types: The first is aimed at solving specific problems in specific systems development; the second is pointed toward exploring intuitively promising research areas that might lead to making a new system possible. The first grows out of the system; the second grows into the system.

Decentralization of management within the former Air Research and Development Command led to assignment of each research project to one of the four organized divisions of ARDC. At least this provided for administrative coverage. But it was obvious there would be a crying need for inter-division organization to keep programs coordinated, to avoid the duplication of tasks, and to make sure all the loopholes were plugged.

That inter-divisional organization is provided by the Technical Area Manager. He works out of a single division, to which have been assigned one or more Technical Areas on the basis of logical competence in that area. But his authority extends across the entire command; his responsibility includes all the problems of across-the-board management, and his cognizance extends to the borders of the state of the art.

He has to be a man who combines technical competence with management ability, and who is respected by his peers in industry and the scientific community.

The TAM is the focal point for a single type of applied research within the command. But since he may deal with several divisions or centers in the command, he has a single counterpart in each so that he can coordinate command-wide research most effectively.

These single counterparts are the TACs—Technical Area Coordinators—assigned by the commanders of the doing agencies to work with the TAM in applied research.

Together the TAM and the TAC represent a vertical slice through the command's applied research; under these individuals is grouped all research in one specific area. This is actually the second type of research, the kind of research that grows out of the state of the art.

Research Monitoring

Monitoring the first type of applied research—the kind that is solving problems of a single system—is the job of Planning Objective Coordinator (POC). He works in horizontal slices through the Air Force's applied research programs, picking up a piece here and a piece there that finally support his assigned planning objective.

Together, these three types of managers keep applied research moving towards its two goals; specific systems and scientific advances.

Technical Objective Documents

U. S. Air Force Systems Command's concept of applied research management divides the subject into the following technical areas, for which Technical Objective Documents have been prepared and which are available:

710A NUCLEAR WEAPONS EFFECTS
1. Nuclear effects on flight vehicle structures, nuclear warheads and electromagnetic propagation
2. Nuclear weapon phenomenon, bomb debris, radiation hazards and thermal radiation

720A NUCLEAR APPLICATIONS
1. Weapon delivery techniques and associated equipment
2. Nuclear weapon application

720B AEROSPACE GROUND EQUIPMENT TECHNIQUES
1. Flight vehicle direct support equipment
2. Basic site equipment and facilities including cryogenic generation, environment control, hazard detection & control, site integration & check-out equipment
3. Packaging, handling and restraint, aspects of logistics
4. Surface-installed launchers for flight vehicles

720F DEPLOYABLE AERODYNAMIC DECELERATORS
1. Deceleration stabilization, control and/or recovery of personnel, flight vehicles, and/or weapons

720H MATERIALS
1. Air Force Materials Program in metals, ceramics, cermets, magnetic, polymeric, textiles, finishes, preservation, electric, electronic, analysis, evaluation and application

730D NAVIGATION AND GUIDANCE
1. Bombing techniques
2. Navigation techniques
3. Guidance techniques for flight vehicles
4. Guidance for military space vehicles

730E FLIGHT CONTROL
1. Attitude control for flight vehicles
2. Flight data sensing & presentation

730F WEAPON FIRE CONTROL
1. Fire control techniques
2. Targets
3. Scoring techniques

730H VEHICLE DEFENSE
1. Active defense techniques
2. Defense system integration

730J COMPUTER & DATA PROCESSING TECHNIQUES
1. Scientific computation
2. Data handling
3. Automatic control
4. Mathematical techniques

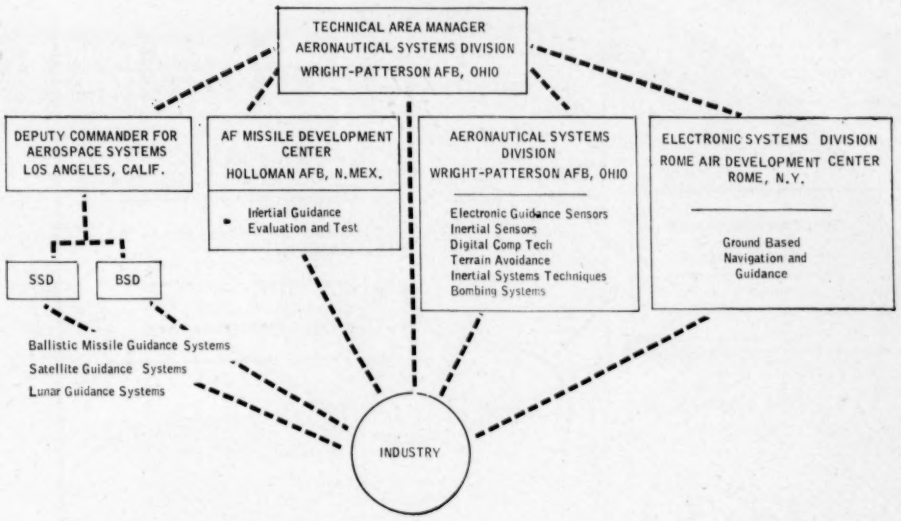
740A ADVANCED WEAPONS
1. Non-nuclear weapons
2. Ballistics

750A MECHANICS OF FLIGHT
1. Flight vehicle structural design
2. Flight vehicle flight dynamics
3. Flight vehicle crew station design and escape techniques
4. Flight vehicle environmental protection
5. Dynamic testing techniques covering

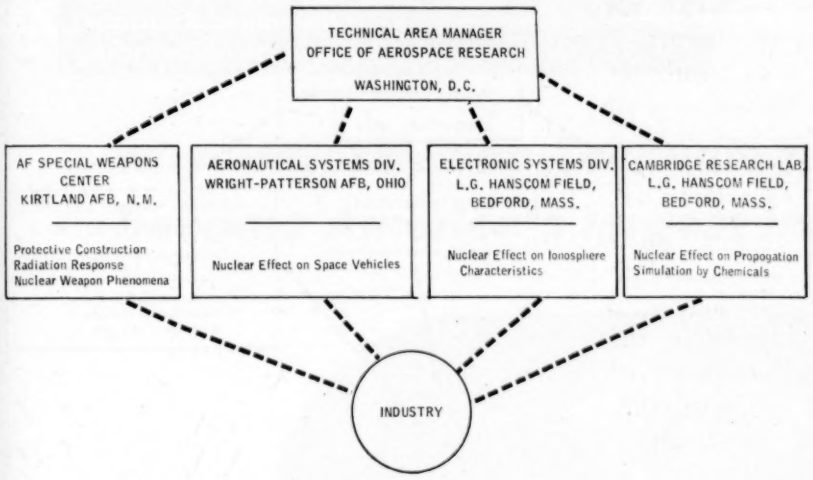
(*Continued on p. 349*)

Technical Area Management Flow Lines Indicated

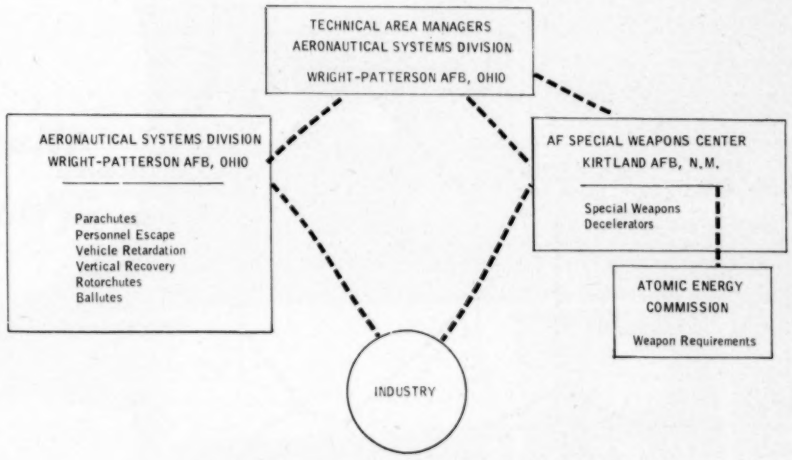
730D-NAVIGATION AND GUIDANCE



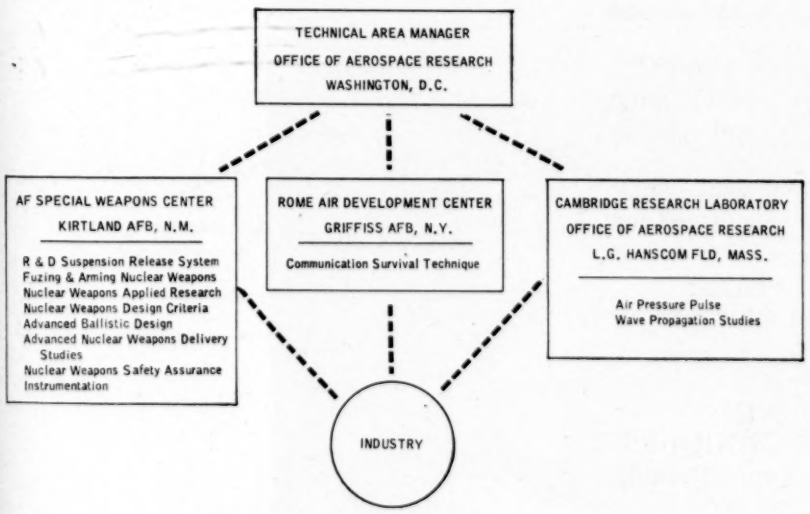
710A NUCLEAR WEAPONS EFFECTS



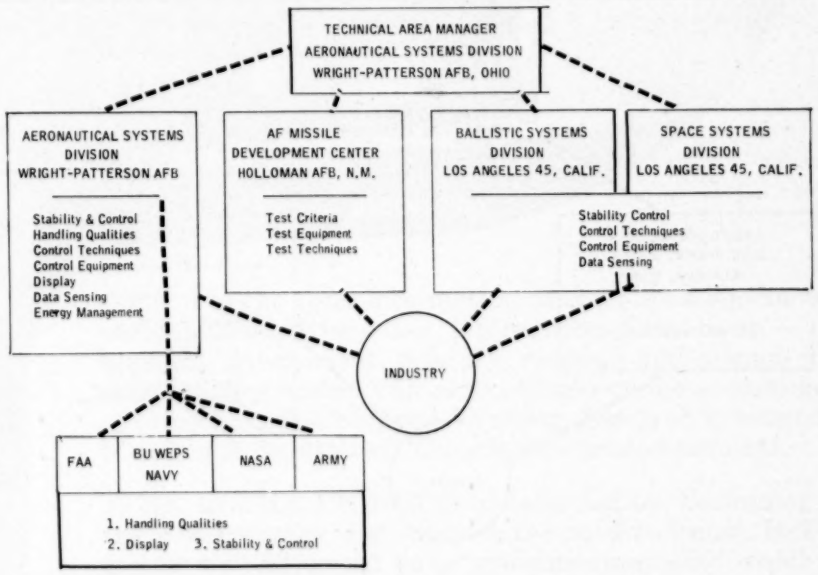
720F DEPLOYABLE AERODYNAMIC DECELERATORS



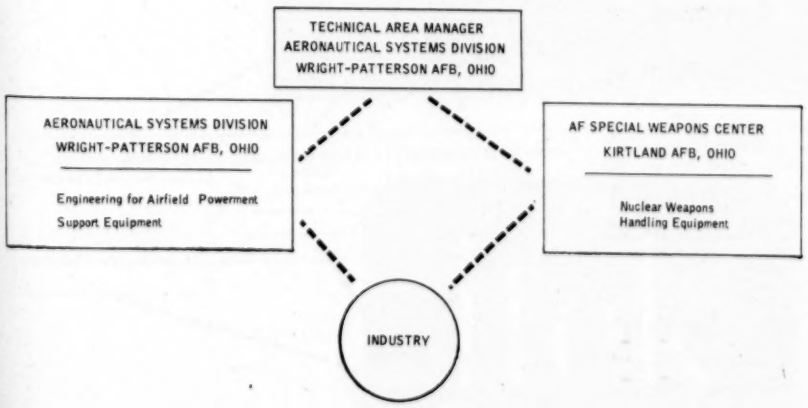
720A NUCLEAR APPLICATIONS



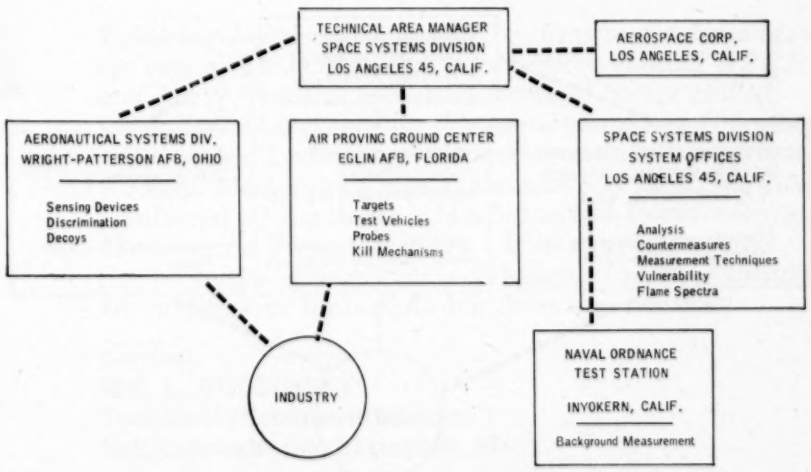
730E FLIGHT CONTROL



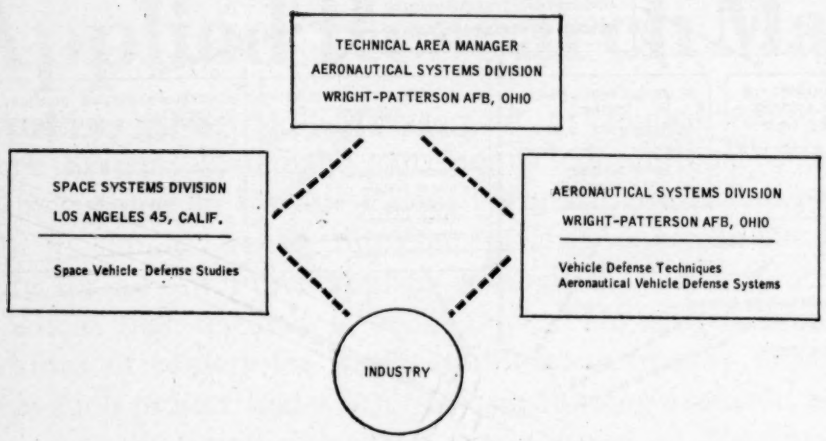
720B AEROSPACE GROUND EQUIPMENT TECHNIQUES



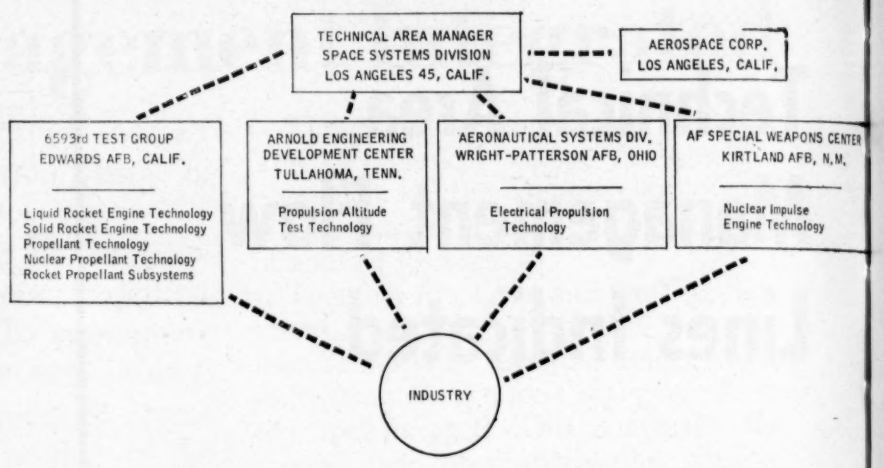
730F WEAPON FIRE CONTROL



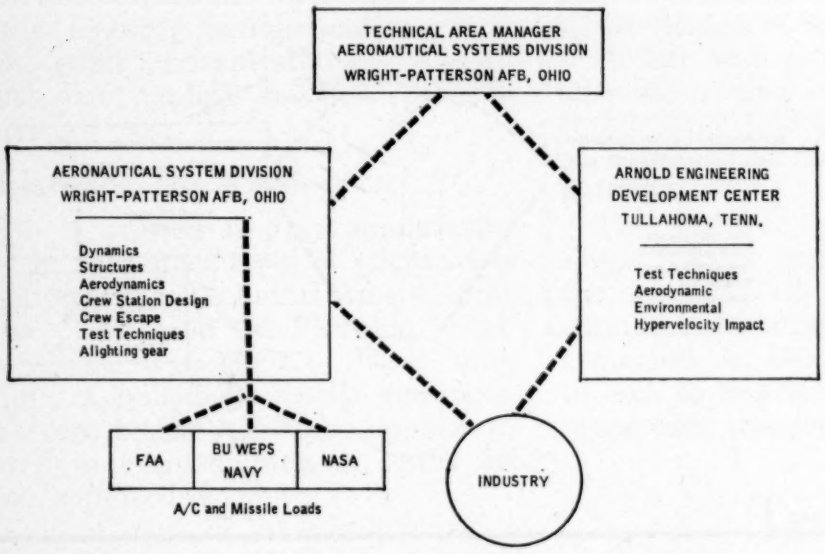
730H VEHICLE DEFENSE



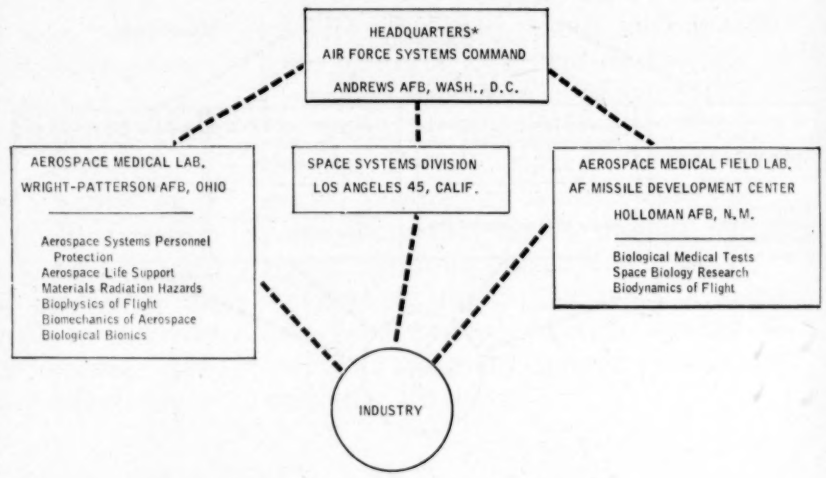
750G ROCKET PROPULSION



750A MECHANICS OF FLIGHT



780A LIFE SUPPORT



*Biomedical Division, Asst. for Bioastronautics, Hq. AFSC

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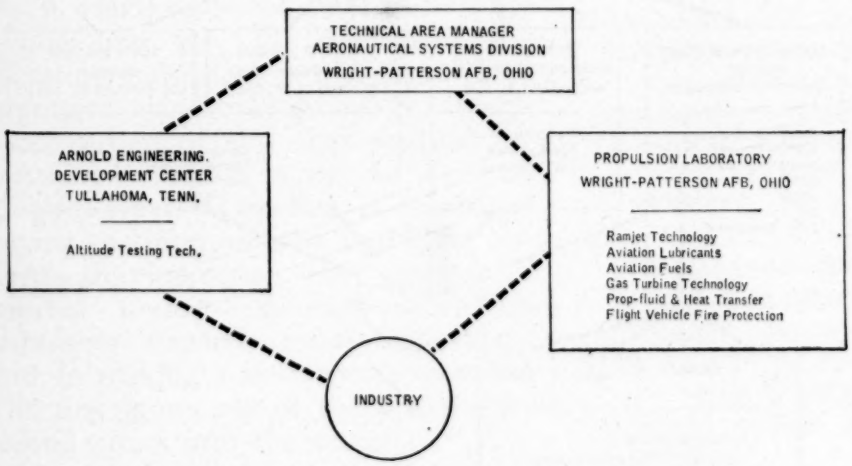
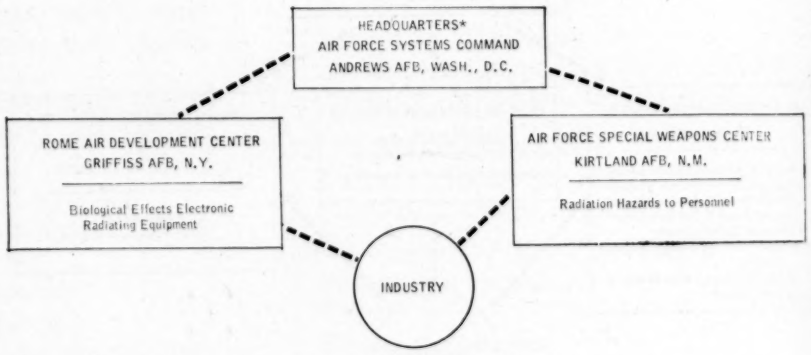


780C RADIOBIOLOGY



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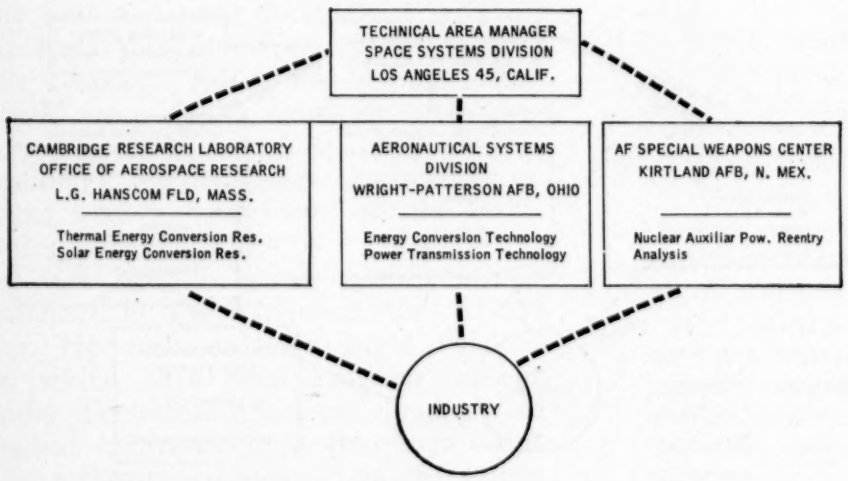
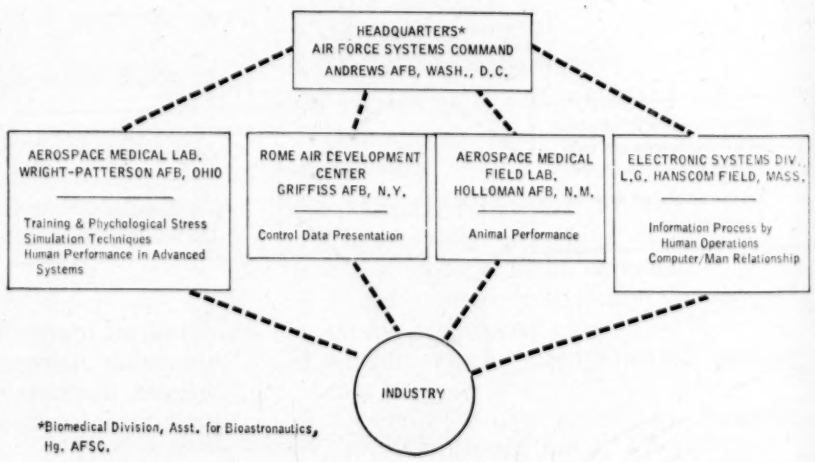
750F FLIGHT VEHICLE POWER



780E HUMAN PERFORMANCE



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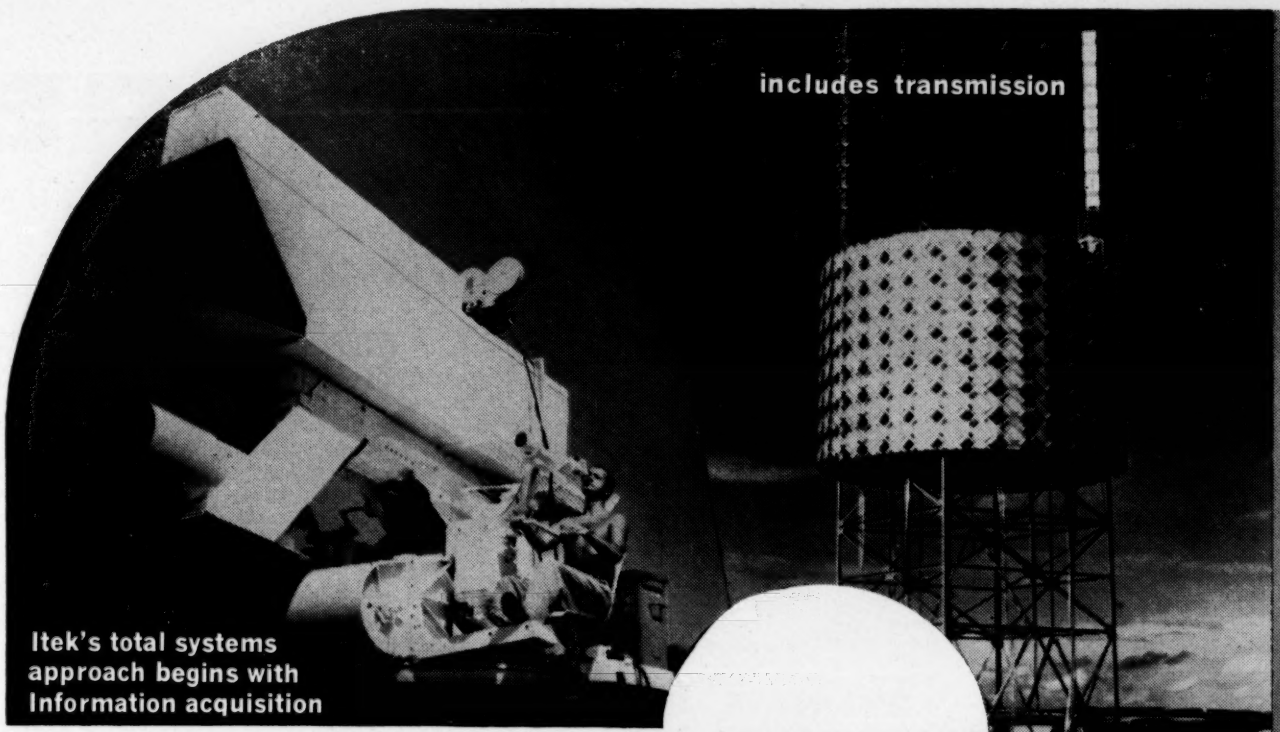

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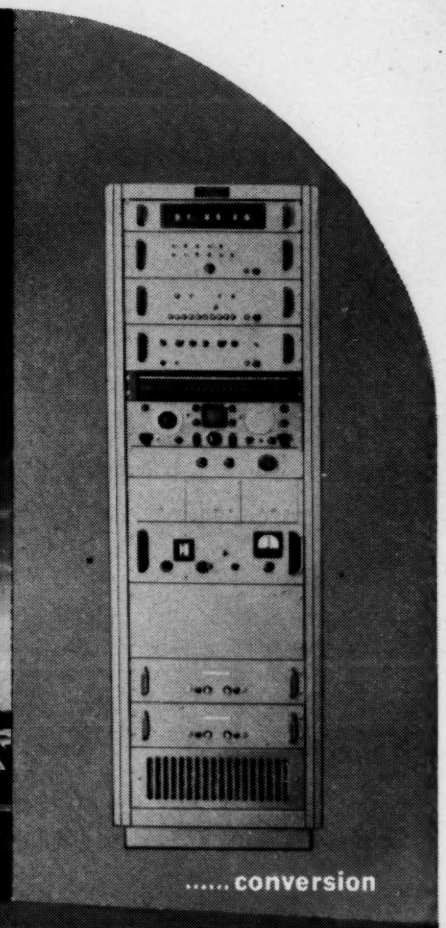

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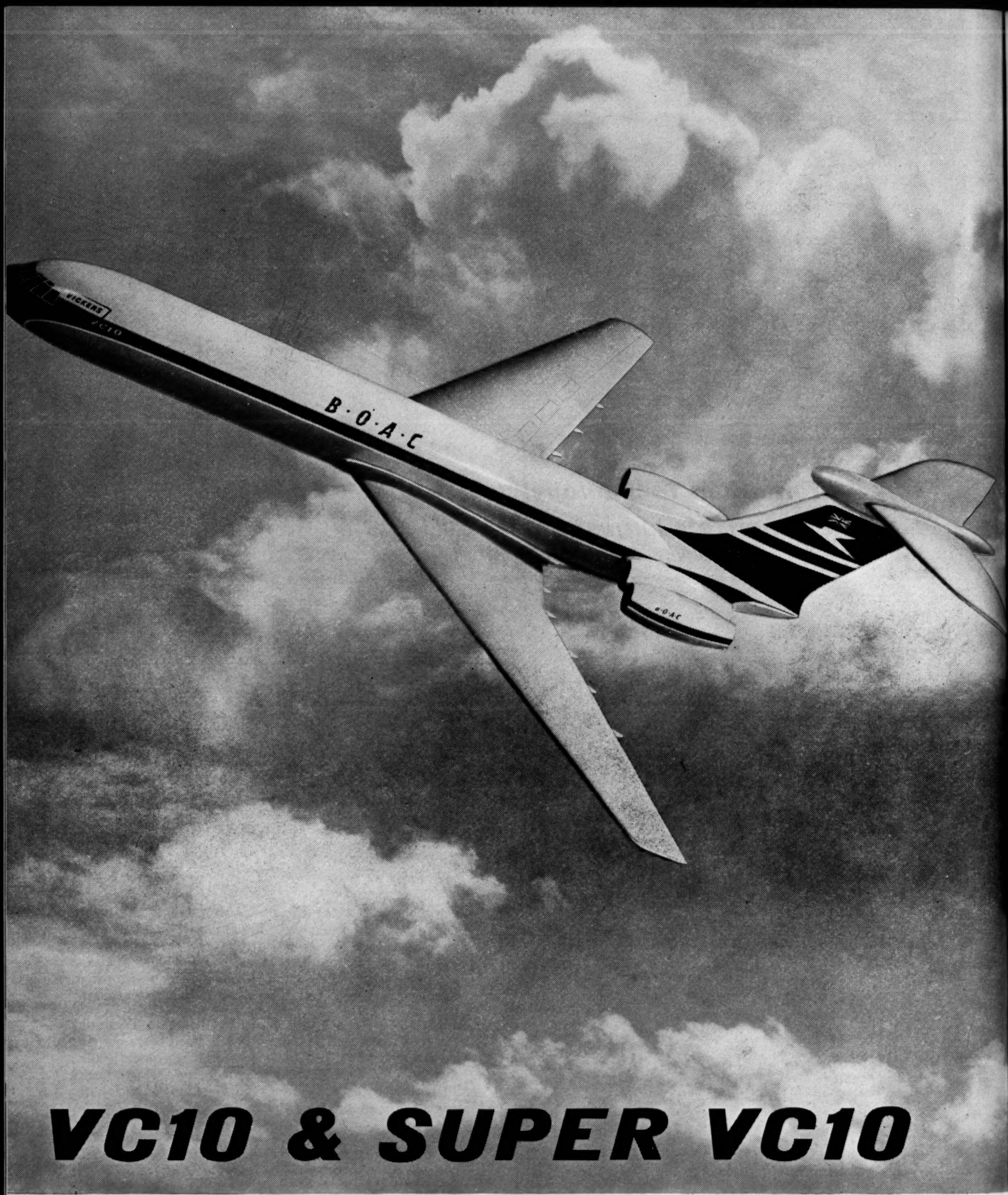

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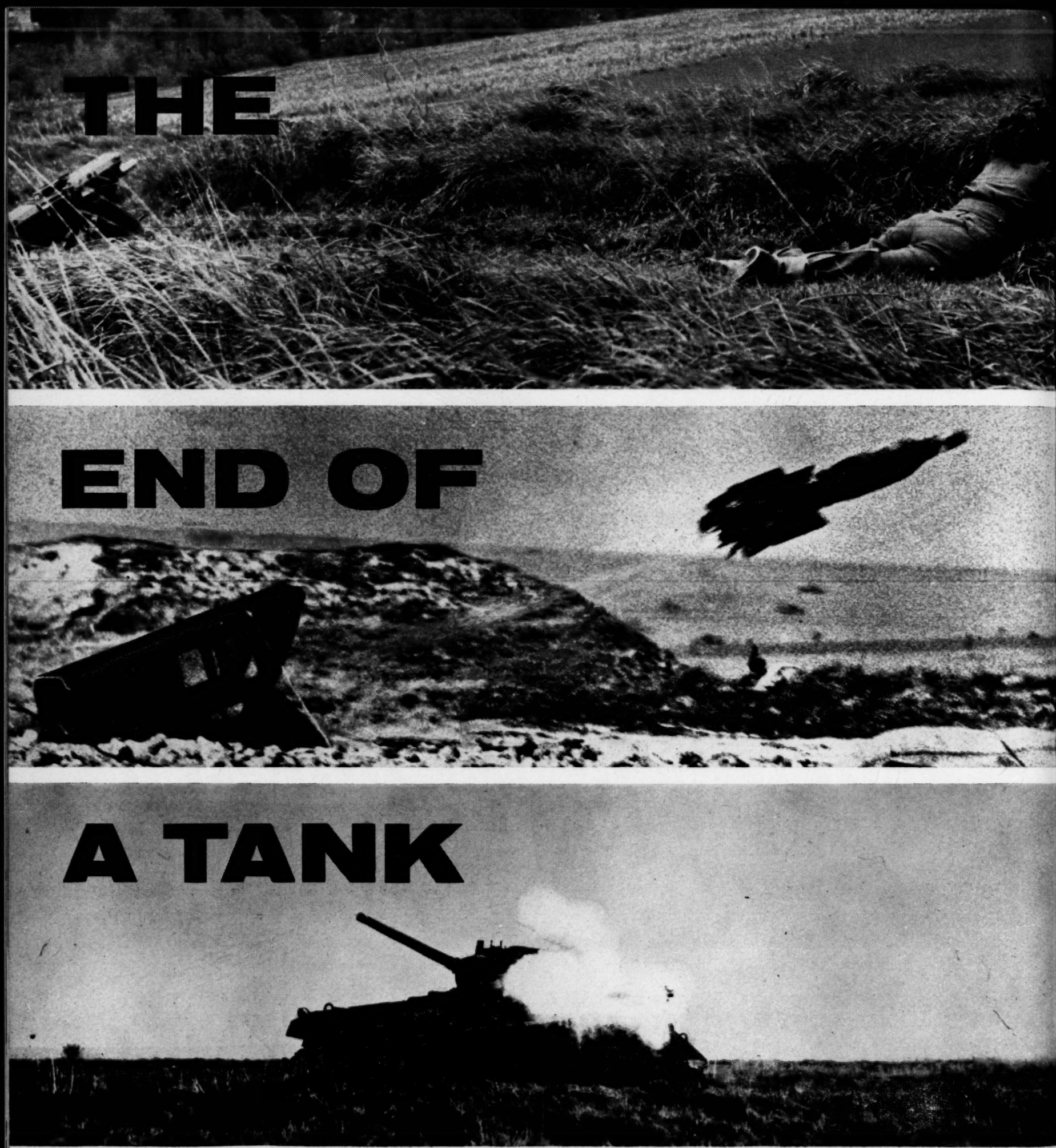

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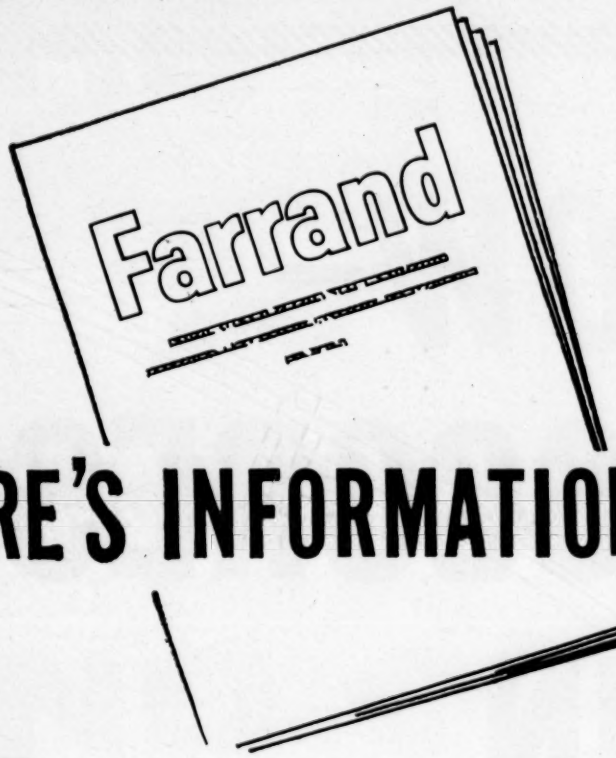

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WHY AIR FORCE HAS ADOPTED MICROFILM FOR ENGINEERING DRAWINGS

Recently the Air Force issued new contract requirements of vital importance to companies that are doing—or intend to do—business with its various activities. In essence, the Air Force has made the use of microfilm mandatory for most engineering data and records relating to items delivered by contractors and their vendors.

The new requirements (MCP-71-77) incorporate standards and specifications issued earlier by the Department of Defense for its Engineering Data Micro-Reproduction System. The Air Force move is indicative of the importance of microfilm to the government in saving time, money, and space.

The Air Force is convinced that working with microfilm is easier than working with paper, that it is more efficient and costs less. Filmwork, in other words, is easier and more practical than paperwork for engineering drawings and records.

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750F FLIGHT VEHICLE POWER
1. All power other than propulsion necessary to operate aerospace vehicles and/or to provide energy at extraterrestrial sites including energy generation, conversion and transmission

750G ROCKET PROPULSION
1. Liquid and solid engines; propellants including electrical and nuclear propulsion; subsystems for same

760B SURVEILLANCE TECHNIQUES
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760C COMMUNICATIONS
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4. Communications theory, analysis and techniques

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1. Ferret reconnaissance collection and data handling
2. Electromagnetic countermeasures

760E ELECTRONIC TECHNIQUES
1. Advanced circuit theory
2. Bio-electronics
3. Electronic tubes and components
4. Molecular electronics
5. Electronic design techniques and reliability

760F RECONNAISSANCE
1. Developing means of collecting reconnaissance data by photographic, airborne radar, thermal microwave, infrared, ultra-violet and television sensors

760G ELECTROMAGNETIC VULNERABILITY REDUCTION
1. Interference measurements
2. Reduction of interference effects
3. Anti-jamming techniques

760H INTELLIGENCE TECHNIQUES
1. Machine data translation and processing
2. Special collection techniques

760K ELECTROMAGNETIC WAVE TECHNIQUES
1. Electromagnetic propagation
2. Electromagnetic interaction with matter
3. Focusing electromagnetic energy

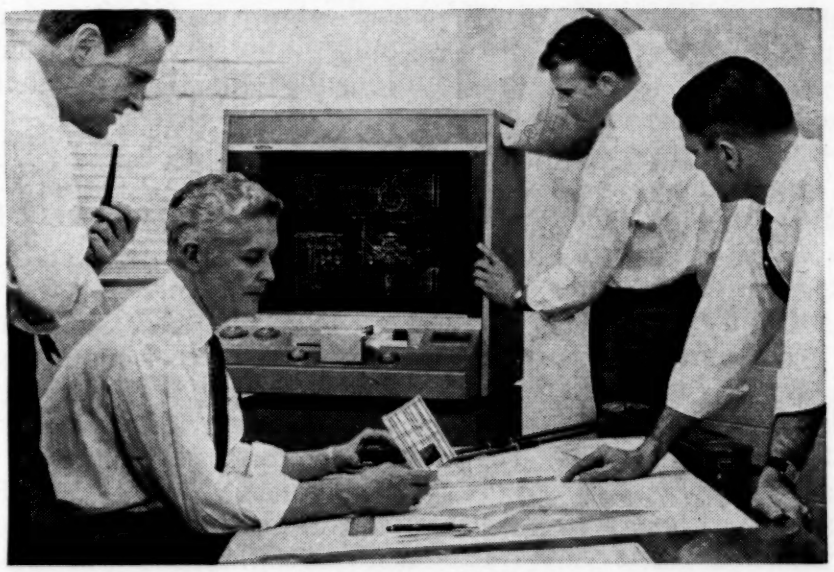
770A AEROSPACE ENVIRONMENT
1. Geodesy and gravity for improved missile accuracy
2. Geomagnetism information for USAF operations
3. Geophysical detection and surveillance techniques
4. Meteorology for operation of Air Force systems
5. Air space properties for design & operations of Air Force systems
6. Astronomy for USAF operations
7. Lunar and planetary exploration

780A LIFE SUPPORT
1. Logistical & mechanical criteria & means to protect & sustain man in AF flight operations. Includes hazards such as low ambient pressure, hypoxia, temperature extremes, and noxious environment and the provision of food and water, rest and disposal of wastes, acceleration subgravity, and zero-gravity, acoustic energy, escape and survival, and vision

780B AEROSPACE MEDICINE
1. Medical support of aerospace operations through improved medical services, disease prevention, health maintenance, etiological assessment and pathological studies of disease courses and establishment of new medical standards

780C RADIOBIOLOGY
1. Radiological criteria and means to protect and sustain man in AF flight operations. Includes the radiation hazards of ambient space, nuclear weapons and reactors, as well as microwave

780E HUMAN PERFORMANCE
1. Training equipment, simulators and techniques for AF systems
2. Selection and use of officers and airmen
3. Human performance in AF systems
4. Information processing and communication for AF systems



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Houston Picked for Space Flight Center

Washington—Harris County, Tex., in the Houston metropolitan area, has been selected as the site for the National Aeronautics and Space Administration's $60-million Manned Space Flight Laboratory.

The laboratory, to be headed by Robert R. Gilruth, director of NASA's Space Task Group, will be located on a 1,000-acre tract which the Humble Oil and Refining Co. gave to Rice University, contingent upon location of the NASA facility there. Rice will now make the tract available to the government.

Location of the laboratory in Houston was predicted by AVIATION WEEK four months ago (May 29, p. 21). Pressure has been increasing steadily from Texas, Massachusetts and Florida congressional delegations to put the new facility in their states. Objections to the Texas move already have been made by Florida and Virginia congressmen.

Although NASA gives a number of reasons for its choice, the Houston move carries a strong political flavor, since Vice President Johnson, chairman of the space council, is from Texas and Rep. Albert Thomas (D.-Tex.) led the political fight to locate the laboratory there (AW Aug. 28, p. 30). He represents a Houston district, which borders the congressional district chosen for the laboratory.

In addition, Rep. Thomas is chairman of the House Independent Offices Subcommittee which considers NASA budget requests. The subcommittee has routinely cut the agency's budget in past years, but did not do so this year.

A site survey team has been studying potential locations for the lab for the past two months, but many in NASA felt this activity was unnecessary. Two weeks ago, one NASA employe commented, "I wonder how many more sites the team will survey before we pick Houston."

Space Task Group personnel, now resigned to the Houston move, would have preferred a Florida site, for its proximity to the Atlantic Missile Range, or an Oakland, Calif. site, which would cause much less disruption in a mass transfer.

One of the top choices of the site survey team was the inactive Benicia Arsenal, near Oakland, which contains 420,000 sq. ft. of air conditioned office and warehouse space. It reportedly is ready for use.

Space Task Group will rehabilitate several temporary structures at Ellington AFB for interim use during the 18 months it will take to build the lab.

Facilities Authorized

Facilities for the new center in Houston already authorized by Congress are:

- **Flight project building,** to house administrative and management offices, computing and data reduction facilities. This eight-story structure, which will be the management, engineering and services center, will cost $12.1 million.
- **Equipment evaluation laboratory** and support building, a structure to be used for component assessment, shops and assembly areas. This facility will cost $13.2 million.
- **Flight operations center,** a single building to consolidate astronaut training, both in simulation and classroom work. Cost will be $3.6 million.
- **Environmental testing laboratory,** containing two test chambers, one of which will be 100 ft. in diameter (AW Sept. 4, p. 37), and one 60 ft. in diameter. These facilities will accommodate complete Apollo spacecraft systems. Cost of this laboratory will be $26.5 million.

NASA expects to spend about $4.5 million on site development and utility installation.

In announcing the Houston move, NASA Administrator James E. Webb pointed out that the manned space laboratory, the Michoud, La., Saturn fabrication site (AW Sept. 11, p. 30), and the Atlantic Missile Range launch site (AW Aug. 28, p. 30), form an integrated network in a temperate climate, with deep water transportation facilities, for the Apollo manned lunar landing effort. He has said all facilities have growth potential for programs beyond Apollo.

When the announcement was made Sept. 20, Space Task Group officials met to discuss arrangements for the move and means of continuing Project Mercury and preliminary Apollo work during the transfer operations. Mercury is in its most critical period, since a manned orbital mission is scheduled before the end of the year.

Apollo Bids Due

A source selection committee from Space Task Group will consider industry bids, due Oct. 9, for the Apollo spacecraft.

From a management standpoint, the most serious concern is that the group does not lose momentum during the move. Added to this problem is the need to hire 800 more people to man the new laboratory before it is completed.

Logistics teams from the group will survey nearby Ellington AFB for temporary quarters, and an advance inspection team went to Houston last Thursday. In this team were Gilruth; his associate director, Walter Williams; Wesley Hjornevik, director of business administration; Martin Byrnes, assistant to Gilruth, and John Powers, public affairs director.

Apollo Chief Named

Washington—D. Brainerd Holmes, 40, general manager of the Radio Corp. of America's Major Defense Systems Division, will become director of manned space flight programs of the National Aeronautics and Space Administration Nov. 1.

This new division is being split from the NASA space flight programs office, directed by Abe Silverstein. Holmes will supervise all manned space flight activities in NASA centers and industry beyond the Mercury project.

His appointment is the first in what is expected to be a general reorganization of NASA to manage the Apollo manned lunar landing program. Holmes was graduated from Cornell University in 1943 with a degree in electrical engineering. After service in the Navy during World War II, he worked for Western Electric Co., Inc., and Bell Telephone Laboratories. He joined RCA in 1953, and for the past 42 months has been project manager of the ballistic missile early warning system (BMEWS) project.

Brooks' Death to Alter Space Group's Course

Washington—Death of Chairman Overton Brooks (D.-La.) of the House Science and Astronautics Committee on Sept. 16 will result in a radical change of course for that committee.

The new chairman, Rep. George P. Miller (D.-Calif.), told AVIATION WEEK that subcommittees will hold more detailed hearings in specialized fields, as opposed to the broad, full-committee approach taken by Rep. Brooks.

"The necessity for long posture hearings is past," Rep. Miller said. He said he hopes to hire technical staff members to serve each of the new subcommittees. Although Rep. Miller is not sure just how the subcommittees will be broken down by subjects, he said he believes the departmental approach followed by the House Armed Services Committee is the best. Under this system, one subcommitttee would cover the National Aeronautics and Space Administration, one of the Defense De-

partment, one the National Science Foundation, etc.

Several other members of the committee feel, however, that the subcommittees should cover specific space technical areas such as propulsion, guidance and life sciences. Their views may prevail in discussions now under way.

Rep. Olin E. Teague (D.-Texas), second ranking Democrat on the space committee, told AVIATION WEEK he favors the subject-by-subject approach. Rep. Teague has a special interest in the life sciences program. He and other members of the House space committee plan to tour government and industry life science facilities in the second week of December. Rep. Teague will head the trip, and all committee members have been invited.

As for committee staff changes, Rep. Miller said there will be no major shakeup. Charles F. Ducander will remain as executive director. Rep. Miller is consulting with several officials outside the House space committee on how it should be organized. They include George J. Feldman, former chief counsel and staff director of the House Select Committee on Astronautics and Space Exploration.

TAC and STRAC to Be Combined; More Reserve Units Are Activated

Washington—USAF's Tactical Air Command and the Army's Strategic Army Command will be combined to form a new unified command under Lt. Gen. Paul DeWitt Adams, now commanding general of the Third Army.

Formal establishment, designation of units to be assigned, writing of employment doctrine and selection of a formal name are expected to be completed before Jan. 1, Secretary of Defense Robert S. McNamara said in a press conference last week. Shortly afterward, the President nominated Gen. Adams for promotion to full general.

McNamara also announced the activation of two additional National Guard Divisions and other reserve units and individuals totaling 73,000 personnel. Active U. S. land force strength within the U. S. with these additions will be 10 combat ready divisions—eight Army and two Marine.

Divisions called were the 32nd Infantry Division of the Wisconsin National Guard, which will be stationed at Ft. Lewis, Wash., and the 49th Armored Division of the Texas National Guard, which will be stationed at Ft. Polk, La.

The Strategic Army Corps is commanded by Lt. Gen. Thomas H. Trapnell, with headquarters at Ft. Bragg, N. C. Gen. Frank F. Everest, commander of the Tactical Air Command, will retire Sept. 30. He will be succeeded at the command headquarters at Langley AFB, Va., by Lt. Gen. Walter C. Sweeney, Jr., who is currently commanding general of the Eighth Air Force, Strategic Air Command.

TAC has more than 49,000 personnel assigned to its three Air Forces. The Ninth Air Force at Shaw AFB, S. C., is composed of tactical reconnaissance, air refueling, troop carrier for intra-theater employment, combat crew training and support elements.

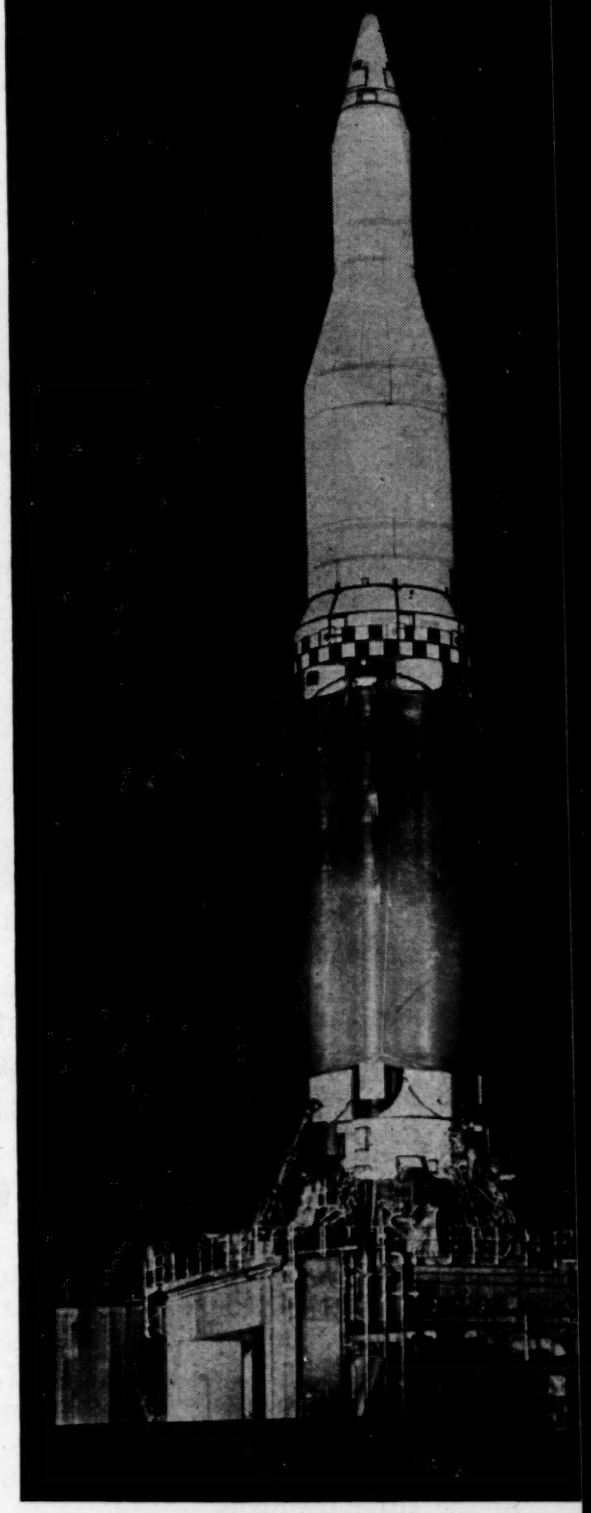
Composite air strike forces comprise the strength of the 19th Air Force, with headquarters at Seymour Johnson AFB, N. C. Aircraft are principally the North American F-100 and Republic F-105 tactical fighter-bombers.

The 12th Air Force at Waco, Tex., is a "paper force" whose mission is to take the necessary elements for an exercise or operational deployment, form and train the groups and send them to operational theaters.

The Strategic Army Corps, with about 115,000 personnel is composed of the XVIII Airborne Corps at Ft. Bragg, N. C., the 82nd Airborne Division at Ft. Bragg, the 101st Airborne Division at Ft. Campbell, Ky., the 4th Infantry Division at Ft. Lewis, Wash. and a large number of combat, combat support and logistical units that are not assigned to divisions.

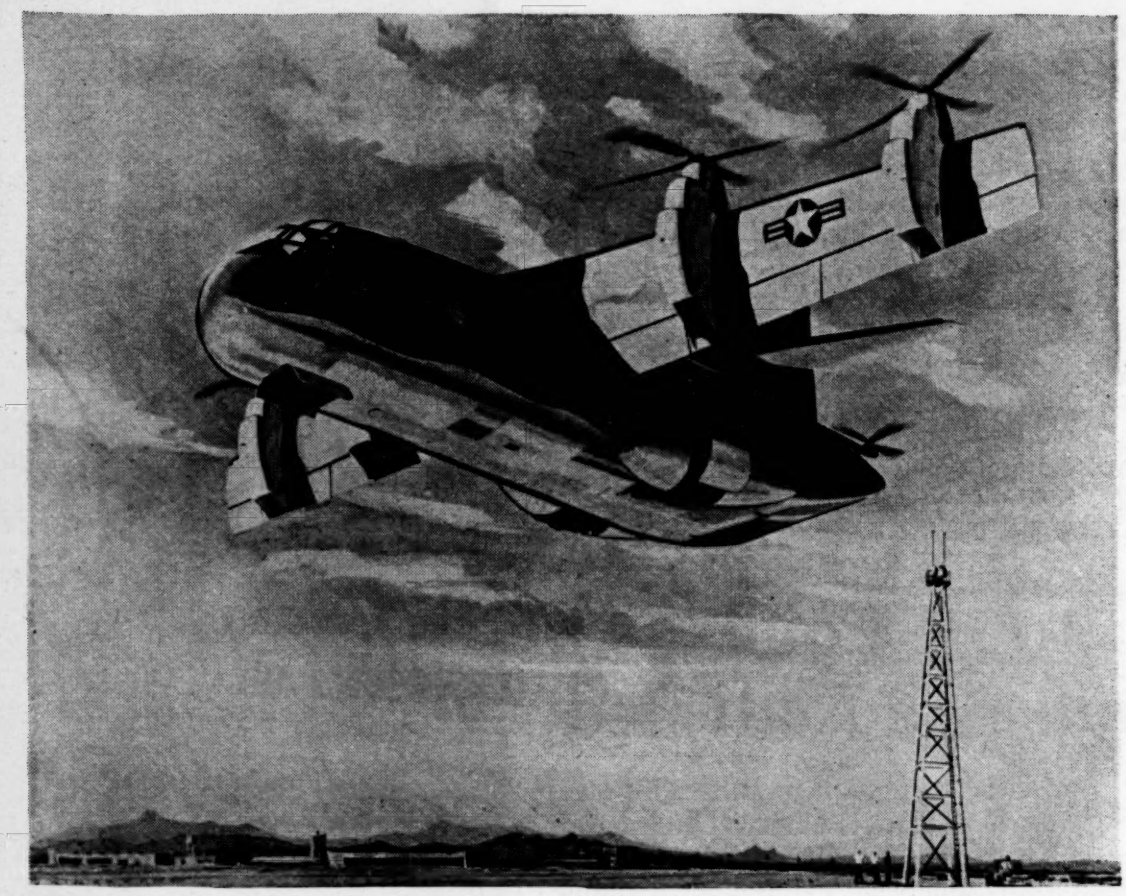
McNamara also said:

- **Use of additional** funds voted by Congress for an additional wing of B-52 or B-58 bombers and development of the Mach 3 B-70 bomber as a complete weapon system: ". . . Congress voted overwhelmingly in favor of these actions, and I think it's incumbent upon us to review the facts again."
- **Use of an additional** $85.8 million voted by Congress for USAF's Dyna-Soar boost-glide vehicle: This is now under reconsideration. Total appropriated for Dyna-Soar is $186 million.
- **Acceleration of the mobile** Minuteman solid-propellant intercontinental ballistic missile program: Emphasis was placed on the fixed-base Minuteman program for Fiscal 1962 because it was further along technically and required concentration of engineering resources. Sen. Henry M. Jackson (D.-Wash.) said last week that the research and development contract with Boeing Co. for mobile Minuteman has been extended from Sept. 15 to Dec. 15. Expenditure rate will be about $5 million a month.
- **Reassessment** of the Nike Zeus anti-missile missile system: "I have recently met with executives of the Bell Labs and Western Electric to review the progress of the Zeus system—not to reassess it, but simply to acquaint myself with the progress and to be sure that everything possible is being done to accelerate its development."
- **Progress report** on U. S. civil defense: A training program of men from local districts has been in progress. They will return to their localities and survey structures for shelter potential, using local engineering and architectural talent. Later on, shelters for 50 million individuals will be equipped and stocked with emergency rations at about $4 a person, or about $200 million, of which $160 million has already been appropriated.



Saturn Booster

First Saturn flight booster, SA-1, is readied for launch from Atlantic Missile Range. Second stage and payload are inert. Launch will be from Complex 34 next month.



FIRST PHOTO of Ling-Temco-Vought, Ryan and Hiller tri-service VTOL transport winning design shows wing tilted 100 deg. for vertical takeoff and landing. The four General Electric T64 turboprops are mounted externally to reduce the need for wing structural cutouts. Outboard sections of the double-slotted full-span flaps are used as ailerons.

L-T-V, Ryan, Hiller to Develop Tri-Service VTOL Transport

Tri-service vertical takeoff and landing transport to be developed by the team of Ling-Temco-Vought, Ryan and Hiller, named by Department of Defense as winner of this competition, will be a tilt-wing configuration similar to that utilized in the X-18 testbed built by the latter company.

However, indications are that the services are also contemplating supplementary research, giving consideration to more advanced designs entered in the competition, which could mean that other companies among the approximately 10 firms entered will still be in the running for further development money. A wide variety of lift configurations, including ducted propellers, tilt rotors and unloaded rotors were submitted, but as predicted by AVIATION WEEK, Feb. 27, p. 33, the severe limitations imposed by the specifications on weight, size and flight endurance probably favored the tilt-wing layout.

Five Prototypes

The development contract award to Ling-Temco-Vought, Ryan and Hiller will involve developing and building five full-scale prototypes and may eventually work into a $70-million to $100-million program, according to industry observers. Initially, Air Force, Army and Navy are contributing $7 million each for Fiscal 1961-1962 and each of the services is expected to continue sharing the remainder of the cost.

Decision to make Air Force program manager was reached when studies showed that meeting Navy's requirements for carrier suitability would pose solid obstacles that would seriously slow the development program. The services then agreed to go ahead with prototype development that would satisfy USAF and Army requirements and that Navy's needs would be considered during development so that they would fit in with minimum revisions after the major engineering and performance problems had been worked out.

Prime Contractor

Under the contract award to the three-company team, Chance Vought Corp.—the aerospace subsidiary of Ling-Temco-Vought—will be prime contractor on the tilt-wing transport. Ryan will build the aft section, including tail, engine mounts and nacelles. Hiller will design and build the transmissions, gearing, shafting and propellers.

Powerplants will be four General Electric T64-GE-6 turboprop engines turning 15-ft. four-blade propellers and a horizontal 8-ft. tail rotor. Tail rotor will incorporate variable pitch blades for effective longitudinal control in the hovering state. Transmission systems will incorporate cross-shafting to connect all powerplants and the tail rotor, so that the airplane will have capability of maintaining flight with any two engines out.

For vertical takeoffs and landings the 67-ft. 6-in. wing will tilt through 100 deg., with leading edge flaps being utilized for suppressing stall outboard of the engine nacelles during transition flight. Since the specifications called for a maximum width of 20 ft., a folding wing provision probably will have to be made in the design to meet Navy's final needs.

The design also exceeds the original specified length of 50 ft., since its length is 58 ft. and the height also considerably exceeds initially specified height of 17 ft., being 26 ft.

Performance Characteristics

Performance characteristics of the VTOL include an estimated top speed of 400 kt., with cruise speed to fall in the specified range of 250 to 300 kt. Combat radius, with 32 fully-equipped troops or equivalent payload of up to 8,000 lb., would be from 200 to 300 naut. mi., while ferrying range with auxiliary tankage would be up to 2,600 naut. mi. empty.

The design utilizes the boxy fuselage layout shown earlier in Chance Vought's V-447 mockup (AW May 1, p. 33), having an unobstructed cargo compartment 30 ft. long, 7 ft. high and 7.5 ft. wide, with tail loading ramp. Fuselage floor is three feet from the ground to facilitate fast loading through the ramp or a side access door.

Landing gear is mounted in streamlined fairings on each side of the lower fuselage. The conventional tricycle arrangement uses low-pressure tires providing a large footprint for operating into unprepared terrain.

'Arms Control Agency' Is Approved by House

Washington—House last week approved legislation authorizing a "U. S. Arms Control Agency" with a 290 to 54 vote.

The main difference between this measure and the legislation previously voted by the Senate establishing a "U. S. Arms Control and Disarmament Agency" (AW Sept. 18, p. 31) is that the new agency would be independent under the House measure, but organized within the State Department under the Senate measure.

The Administration plans a $3.9-million Fiscal 1962 allocation for the agency. This would permit an expansion of the present staff of approximately 100 in State Department's disarmament division to 180 during the year.

11 Records Claimed For Soviet Seaplane

Moscow—Soviets are claiming 11 world records for a jet seaplane designed by G. M. Beriev—apparently the Be-8 (AW July 17, p. 28). The records were set over a period of several days.

The Soviets say the aircraft set a world speed record for seaplanes of 910 kph. (566 mph.) on a base of 15-25 km. (9.3-15.5 mi.). The airplane's average speed was 875.86 kph. (544.26 mph.) over a 1,000-km. (621.4-mi.) closed course with a payload of 5,000 kg. (11,025 lb.), thus setting records in this category without payload, and with payloads of 1,000 kg. (2,205 lb.), 2,000 kg. (4,410 lb.) and 5,000 kg.

The jet seaplane, according to the Soviets, also lifted a payload of 5,000 kg. to an altitude of 14,042 meters (46,071.8 ft.).

Simultaneously, records were set for lifting payloads of 1,000 kg. and 2,000 kg. to that altitude.

A payload of 10,000 kg. (22,050 lb.) was lifted to 12,700 meters (41,668.7 ft.) and 15,000 kg. (33,075 lb.) to 12,120 meters (39,765.7 ft.). During the same flight a record was set for lifting a maximum payload of 15,204 kg. (33,128 lb.) to an altitude of 2,000 meters (6,562 ft.). Without payload, the seaplane reached an altitude of 14,742 meters (47,368 ft.). Tass, the Soviet news agency, said substantiating documents will be submitted to Federation Aeronautique Internationale for approval as world speed records.

Nuclear Box Score

Washington—Box score of 14 Soviet Russian nuclear weapons tested in the atmosphere between Sept. 1 and late last week is as follows:

- **Sept. 1. Semipalatinsk area, Central Asia. Substantial yield in the intermediate range.**
- **Sept. 4. Semipalatinsk. Low kiloton range.**
- **Sept. 5. Semipalatinsk. Low to intermediate range.**
- **Sept. 6. East of Stalingrad. Low to intermediate range.**
- **Sept. 10. Area of Novaya Zemlya, north of European Russia. Several megatons.**
- **Sept. 10. Novaya Zemlya. Low to intermediate range.**
- **Sept. 12. Novaya Zemlya. Several megatons.**
- **Sept. 13. Semipalatinsk. Low to intermediate range.**
- **Sept. 13. Novaya Zemlya. Low to intermediate range.**
- **Sept. 14. Novaya Zemlya. Several megatons.**
- **Sept. 16. Novaya Zemlya. On the order of one megaton.**
- **Sept. 17. Semipalatinsk. Intermediate yield.**
- **Sept. 18. Novaya Zemlya. On the order of a megaton.**
- **Sept. 20. Novaya Zemlya. On the order of a megaton.**

Two U. S. tests, conducted underground, were as follows:

- **Sept. 15. Nevada test site. Low yield.**
- **Sept. 16. Nevada test site. Low yield.**

Soviet Rocket Tests Spur Space Forecasts

Ballistic rockets being test fired into the Pacific Ocean by Soviet Russia may soon launch spaceships weighing 16,000 to 20,000 lb. and carrying "entire space teams in flights around the earth or around the moon," according to radio broadcasts from Moscow to Communist East Germany.

One broadcast said the spacecraft could also be used as "ships for the building of large, permanent space stations," and cited an article in the Soviet newspaper Pravda which said that Russian scientists "are about to make plans under which the moon's surface would be used as the starting place for flights to other planets."

Russia launched "multistage carrier rockets" into the Pacific on Sept. 13 and Sept. 18. Each traveled more than 7,450 mi., Russia said. The first landed "less than 1 km. (0.62 mi.) from the target" and the second landed "in immediate proximity to the spot where the first rocket" landed, Russia said.

There will be more shots in this test series—contrary to the pattern last year, when Russia launched two rockets in January and two in July in separate test series.

A Moscow broadcast to Spain said the Pacific tests indicate that Russia is on the threshold of "new and complicated investigation of the universe." Thrust of the rockets exceeds the 20 million hp. of those which launched Vostok I and II, the broadcast said.

Another East German broadcast speculated that the rockets being tested might be intended for "a direct defense against approaching weapons carriers and weapons systems"—apparently a reference to an anti-missile missile. An East German commentator also recalled that the Russian test firings in January of 1960 were followed in May of that year by the first launching of a five-ton spaceship. The July, 1960, tests were followed by launchings of seven-ton spaceships.

"It can be assumed, therefore, that the tests of the further-developed rockets . . . will, within the foreseeable future, be followed by new, breathtaking flights of Soviet spaceships," the East German broadcast said.

AEC's Rover Funds Progress In Senate

Washington—Senate Appropriations Committee last week approved a $42-million Fiscal 1962 appropriation for Atomic Energy Commission for the Rover rocket propulsion reactor program—a substantial increase over the $23.5 million for Fiscal 1961.

This was the full amount requested by AEC and previously voted by the House.

AEC's Fiscal 1962 requests were also approved by the House and Senate committee for these programs:

- **Snap satellite** and small power sources program; $25.5 million, compared with $17.2 million for Fiscal 1961.
- **Pluto missile** propulsion reactor program; $23 million, compared with $22.1 million for Fiscal 1961.
- **High-temperature** materials and high performance reactor research program; $19.9 million. This entails research for aircraft nuclear propulsion.

Space Communications Hearings Are Delayed

Washington—Hearings before Senate Small Business Monopoly Subcommittee on ownership and operation of a space communications system, originally scheduled for Oct. 17, have been postponed until early November (AW Sept. 4, p. 32).

A committee of 10 international common communications carriers, appointed by FCC, will submit its recommendations before Oct. 13.

Sen. Russell Long (D.-La.), chairman of the subcommittee, postponed the public hearings after FCC pointed out that a period of 15 days following Oct. 13 has been set for all interested parties to submit their views on the recommendations of the 10-carrier committee.

Vela Hotel Funds

Washington—Initial funding of approximately $14 million for a contract to build nuclear detection satellites under the Vela Hotel program is expected to be allocated soon. Air Force Space Systems Division and Aerospace Corp. have made presentations to Defense Department's Advanced Research Projects Agency on the merits of industry proposals. Winner of the competition will build the spacecraft and integrate instrumentation into the spacecraft.

Space Technology Laboratories, Inc., is believed to be the leading contender. Another version of Vela Hotel, oriented to measure any U.S. nuclear space explosions hasn't been made formal by ARPA to the point of asking for bids.

Eastern, Mohawk, National Airlines Propose Absorption of Northeast

Eastern, Mohawk and National airlines last week combined forces to propose the acquisition and dismemberment of Northeast Airlines in a move to reduce competition on New England-Florida routes and ease subsidy requirements on local New England routes.

The proposal, which will still require formal approval of the Civil Aeronautics Board if it is accepted by Northeast, calls for a transfer of Northeast's New England routes to Mohawk and some adjustment of these routes. Northeast's routes extending south of New England to Florida would be absorbed by Eastern and National.

The proposal was announced jointly by Eastern, Mohawk and National and the offer was made in writing to David A. Stretch, chairman of Northeast, by the presidents of the three airlines—Malcolm MacIntyre, Robert E. Peach and G. T. Baker, respectively.

The three carriers offered this three-way combination to Northeast in exchange for the assets and other considerations of Northeast:

- **Common stocks** with a current value of approximately $3 million.
- **Warrants of additional** stock which has a current market value in excess of $10 million.
- **Convertible subordinated** notes amounting to $10 million.

If the offer is accepted, a merged Mohawk and Northeast will hold the principal assets, routes and property of Northeast and will arrange settlement of Northeast's obligations. Southern routes, which Northeast has been operating under a temporary certificate for the past five years, would be operated by National and Eastern in direct competition with one another.

As of late last week, the proposal was being given serious study by Stretch. In addition to being chairman of Northeast, he is president of the Atlas Corp., which holds a majority control in Northeast.

The new company would acquire Douglas DC-6B fleets, subject to existing loan agreements with Chase Manhattan Bank on the DC-6Bs and subject to acceptance of convertible subordinated notes on the Viscount aircraft, to be issued by the new company.

Eastern has proposed assumption of leases on three of the six Convair 880 turbojet transports leased by Northeast. Eastern and National would consider handling the disposition of the leases on the three remaining 880s. Industry observers feel that either TWA or Delta will be quick to pick up such leases. Leases on both engines and airframes are terminable.

Northeast would receive 460,000 shares of Mohawk common stock, 10-yr. warrants for 100,000 shares of Mohawk common, 10-yr. warrants for 300,000 shares of Eastern common, and 10-yr. warrants for 200,000 shares of National common. Total of $10 million convertible subordinated notes of Eastern and National would be given to Northeast.

Eastern would issue $7 million in notes, National $3 million. Notes would mature in 25 yr. and bear an interest rate of 5%. They would be convertible into common shares of each company at a price 50% above the average price of the shares during a specified period. Warrants provide for a purchase price of the common stock of the three airlines at 33.33% above the market value of the shares during a specified period. Minimum prices have been set at $8 per share for the Mohawk stock, $32 for the Eastern stock and $18 for the National stock.

Other terms included in the agreement are:

- **Provision that the CAB** recognize that operations of the permanently certificated New England routes of Northeast are eligible for federal subsidy.
- **Merged companies** will be relieved of debt held by the Hughes Tool Co. and the Atlas Corp.
- **Merged companies** will have no responsibility for payment of Northeast's trade accounts outstanding at the time of merger except by application of current Northeast assets.
- **Any shares of common** stock of Mohawk, Eastern or National or any warrants for the purchase of such common shares that might be issued to Hughes Tool Co. or Atlas Corp. shall be placed in a voting trust. Hughes Tool has an 11% interest in Atlas.
- **Merged companies** will withdraw Northeast's pending application for renewal of Northeast's temporary operating authority to serve points south of New York.

American 990 Deliveries

New York—Under a new contract signed last week by American Airlines and General Dynamics Corp., the airline will take 15 Convair 990 jet transports in their present below-speed-guarantee condition (AW Sept. 18, p. 40), and the manufacturer will come up with a modification not later than February, 1963.

If General Dynamics does not produce the fix, the contract is voided and American could turn back the planes. Required modification would bring the maximum cruise thrust speed to at least 610 mph. at 21,200 ft., which is still short of the original guarantee of 620 mph. under the same conditions.

If General Dynamics can bring the speed up to the original 620 mph., American will buy five more 990s. This still is five airplanes short of the original order of 25.

The 15 unmodified aircraft will be delivered by June, 1962, with the first two units turned over to American in December. American plans service with the airplane during the first quarter of next year. Certification is expected by Dec. 31.

American was to lease the General Electric CJ805-23 fan engines in the 990 but, under the new contract, the lease will be taken over by General Dynamics.

The drag problem also has brought the 990's stall speed to a higher value than originally guaranteed. Also affected are range and fuel consumption.

The unmodified aircraft are guaranteed to make 584 mph. under the above conditions, 36 mph. below the original guaranteed speed. But American says the airplane will be scheduled with the same times as its current jet fleet of Boeing 707-120Bs and 720Bs.

If General Dynamics makes the fix as specified, even if the 620 mph. speed is not achieved, American still can promote the 990 as the fastest jet transport.

Hammarskjold, Rabat, O'Hare Crashes Probed

Investigators last week began examining conflicting reports on the circumstances surrounding the crash in Northern Rhodesia of a Swedish Air Co. Douglas DC-6B which took the lives of United Nations Secretary General Dag Hammarskjold and 12 others on Sept. 18.

The possibility of sabotage or aerial attack arose after the lone survivor said the plane was rocked by a series of explosions just before it plunged to earth in a forest preserve eight miles north of Ndola. As of late last week, neither possibility had been ruled out.

The aircraft, piloted by Capt. Per Hellonquist, left Leopoldville at 5:20 p.m. Sept. 17 for the 1,100-mi. flight to Ndola, normally a four-hour trip. However, he apparently followed a dog-leg route to avoid Katanga, and did not report over Ndola until 12:12 a.m. Sept. 18.

Ndola authorities say the pilot was promptly given clearance to land. There were conflicting reports, however, that the Ndola tower asked

Hellonquist to identify himself and he refused. These reports said he then asked and received permission to descend to 6,000 ft., but instead the aircraft climbed out and disappeared to the north with no explanation from the pilot.

Meanwhile, no solid clues emerged in the crash Sept. 17 of a Northwest Airlines Lockheed Electra shortly after takeoff from Chicago's O'Hare Field, which killed all 37 persons aboard.

Preliminary analysis ruled out sabotage or structural failure, according to Civil Aeronautics Board Chairman Alan S. Boyd. The aircraft had been modified to eliminate high-speed vibration problems.

The pilot's message, "no control," was the only understandable transmission from the Electra recorded in O'Hare's control tower. The others were garbled. Federal Aviation Administrator Najeeb E. Halaby said the tower's tape will be subjected to "the finest scientific analysis in the country." Federal Aviation Agency spokesmen also said the accident would spur efforts to equip transports with cockpit voice recorders.

Witnesses estimated the Electra reached an altitude of 200 to 500 ft., banked sharply, and crashed. It apparently never achieved normal climb airspeed.

In another accident, reports from Rabat, Morocco, said an Air France Caravelle attempting to land in a heavy fog and zero visibility at Rabat Airport had been waved off once before it crashed Sept. 12 as it was going around for a second attempt. All 77 persons aboard were killed. The Rabat Airport is not equipped with an Instrument Landing System.

Pilots Inject Doppler Issue Into TWA Talks

Washington—Trans World Airlines pilots have stated they will refuse to operate international flights without a navigator until the company and Air Line Pilots Assn. agree on a new contract covering pilots' wages and working conditions.

The pilot group also requested a "formal proposal" from TWA before the carrier makes a dual doppler radar system the primary means of navigation on its overseas schedules (AW Sept. 18, p. 40).

Federal Aviation Agency evaluation of TWA's doppler system was continuing last week after a federal court rejected a request, filed by the airline's professional navigators, for an injunction that would bar such tests. Earlier, the navigators had threatened to strike if Federal Aviation Agency went ahead with its evaluation.

National Captains Bar Copilots From Landing

Washington—National Airlines' captains are refusing to share landings with company copilots to protest the one-month grounding without pay of Capt. Vincent J. Andress, whose copilot made a hard landing here and forced National to cancel a flight.

The pilots' action, if continued for more than 90 days, probably will force National to schedule a large number of flights for training purposes only. This is because captains and copilots alike must execute at least three landings every three months in order to retain their currency in a given type of equipment.

National pilots feel that the punishing of a captain for the errors of his copilot is a policy that places the captain in constant jeopardy. As a result, National captains agreed to do all line flying and not to aid the company in maintaining copilot proficiency.

According to Lewis W. Dymond, National's vice president-operations, Capt. Andress "failed to exercise the skill, care and judgment required of an airline captain" in that he allowed his copilot to land a Douglas DC-7 50 ft. short of runway threshold at Washington National Airport. Minor damage was sustained.

Flickinger Sees Need For New Space Force

Washington—Creation of a Space Force as a fourth service was called for last week by Brig. Gen. Don Flickinger, who retired Aug. 31 as deputy for bioastronautics in the Air Force Systems Command.

Gen. Flickinger said the Space Force should have a military structure, but without the limitations of relatively low civil service salaries or the need to keep what he called "incompetents." He said the U. S. is a full generation behind the Soviet Union in science and technology, and suggested that the method to solve bioastronautics problems is integration of bioastronautics with engineering throughout the entire life of a space program.

He said the most critical problem in manned space flight is ambient ionizing radiation, a problem which so far has been "undersold" by the U. S. Sources of this radiation are solar flares and more distant, as yet unidentified bodies in space.

Gen. Flickinger, now an independent bioastronautics consultant, said he is certain the Soviet Union will be the first to land a man on the moon, and that the U. S. will not accomplish it during this decade. He said the USSR may be utilizing new techniques in bioastronautics research, but in general medicine, the Soviet Union is stressing preventative techniques.

Bioastronautics Shift

Washington—Air Force Systems Command will form a Bioastronautics Division, effective Oct. 1, which will consolidate all USAF applied research in bioastronautics into a single element.

The move follows a recommendation by AFSC and was approved last Thursday by USAF Headquarters. Principal element to be transferred to Systems Command will be the School of Aerospace Medicine, now under the jurisdiction of Air Training Command.

News Digest

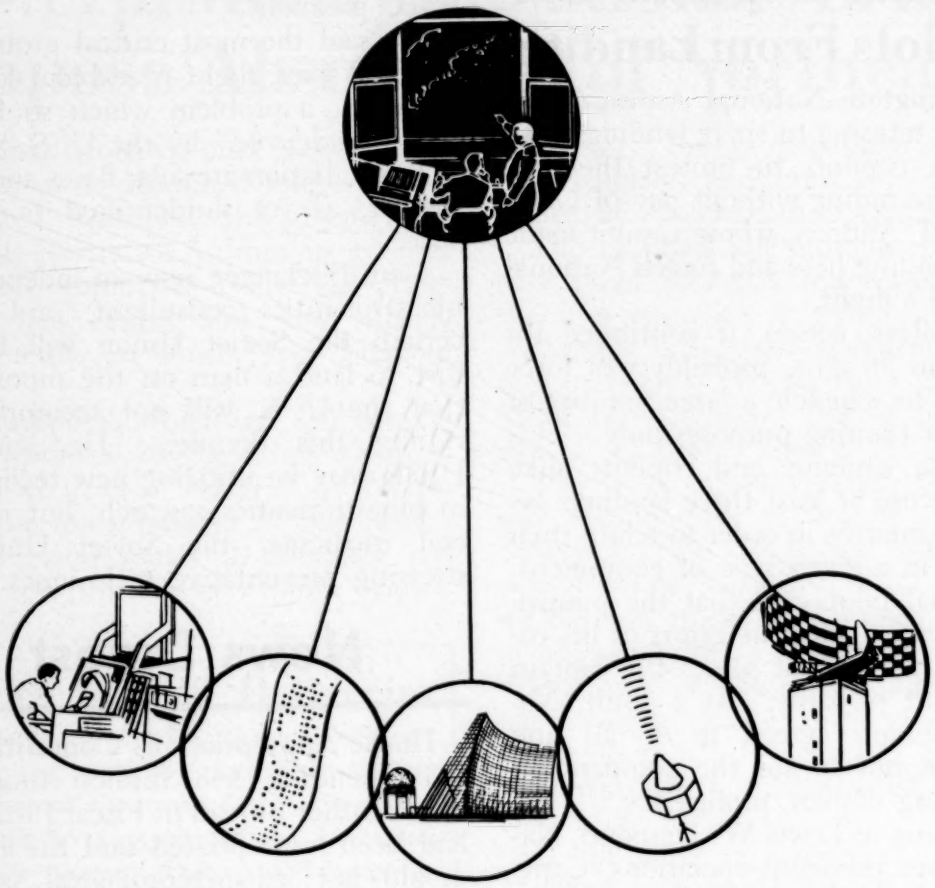
House Appropriations Committee, in recommending $48 million more for the Weather Bureau in Fiscal 1962 than had been appropriated said the bureau should put its meteorological satellite system "into operation immediately as it has a day-to-day bearing on everybody." Weather Bureau asked for $53 million supplemental appropriation, with $38 million of that amount slated to go for launching and building of three Nimbus satellites.

Soviet Union has "in considerably larger measure" than the U. S. the "basic protective means and facilities" for protecting its civilian population against nuclear bombing, according to a House Government Operations Committee report released last week. The report said that President Kennedy's civil defense program should not be regarded as the complete effort but as "a first step in a well-organized, progressively developing civil defense program."

Frank E. Loy, a Los Angeles attorney, has been named Special Assistant to Federal Aviation Administrator Najeeb Halaby in Halaby's role as presidential aviation adviser. Loy will assist Halaby in implementing portions of Project Horizon designed to develop national aviation goals for the next decade.

Dr. Edward T. Welsh, executive secretary of the Space Council, last week asked the Senate Appropriations Committee for an extra $225,000 for Fiscal 1962 to hire additional staff members, and for authority to hire staff personnel without going through Civil Service procedures.

Discoverer XXXI re-entry capsule failed to separate from its Agena B spacecraft on command from the ground station at Kodiak, Alaska, last week,



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but Discoverer XXX was recovered in the first successful air snatch retrieval by a turboprop Lockheed JC-130B.

Douglas Aircraft Co. plans to close its El Segundo, Calif., plant and transfer its functions to the Long Beach plant, causing the layoff of 1,650 employes at El Segundo and hiring of 1,400 at Long Beach.

Award of the Apollo guidance contract to the Massachusetts Institute of Technology, rather than to a private electronics firm, brought an objection by Rep. Steven B. Derounian (R.-N. Y.) in a letter to President Kennedy.

Lockheed-California Division of the Lockheed Aircraft Corp., Burbank, Calif., has received a $92.7-million contract for the production of P3V-1 Orion anti-submarine aircraft.

Contractors holding military, space or atomic energy defense orders who suffered damage from Hurricane Carla are eligible for priorities assistance from Business and Defense Services Administration. Contact is George Malherbe, Houston Field Office, U. S. Department of Commerce, Houston 2, Texas.

Air Force Logistics Command will consolidate supply and cataloguing activities now being conducted at 11 installations into one Cataloguing Group located at Wright-Patterson AFB, Ohio, by the end of December.

Air Force Systems Command and its Aeronautical Systems Division's Skybolt system project office are concerned about engineering costs on this Douglas air-to-ground ballistic missile and aspects of delay in program schedule. Recent engineering change will substitute conical re-entry vehicle configuration for former cylindrical re-entry body.

Rear Adm. William A. Schoech, commander-designate of the 7th Fleet, has been nominated for the rank of vice admiral, and Col. Godfrey T. McHugh, President Kennedy's Air Force aide, has been nominated for the rank of brigadier general.

Hawker P.1127 VTOL strike aircraft (AW cover, Sept. 4) last week made its first successful transition from vertical takeoff to hover and then to forward flight.

President Kennedy last week announced creation of an interagency steering committee to study U. S. air transport policies and programs. The group will be headed by Federal Aviation Agency Administrator Najeeb Halaby, as originally pointed out by AVIATION WEEK (Aug. 21, p. 49).

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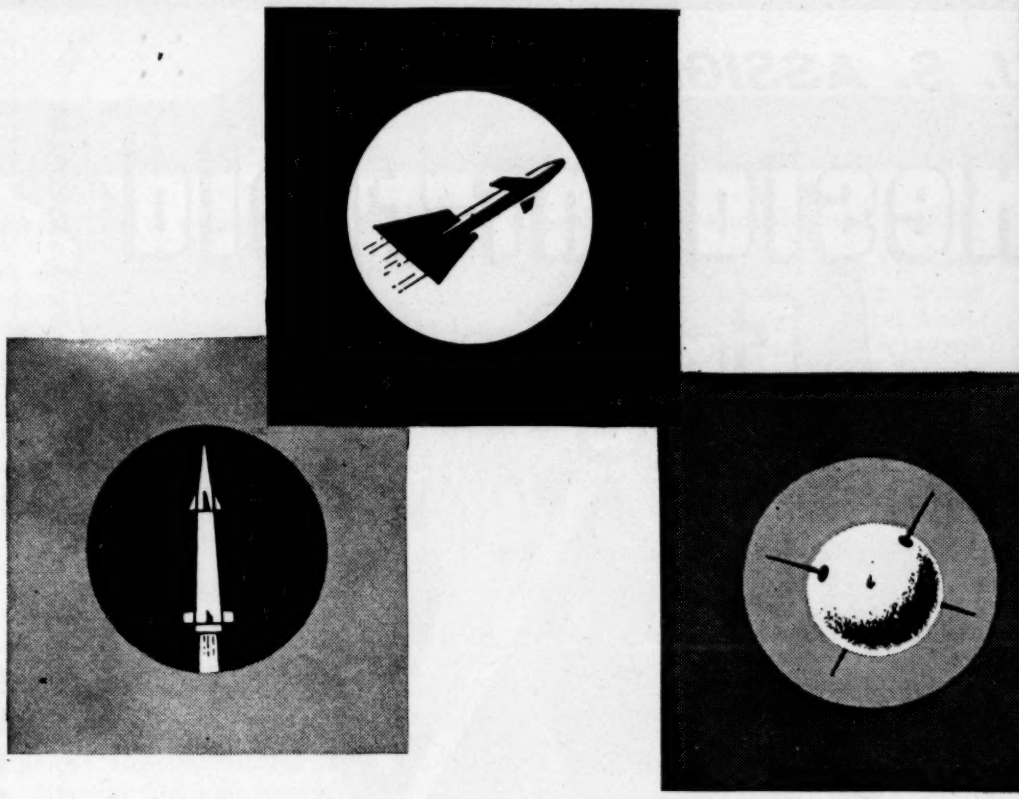

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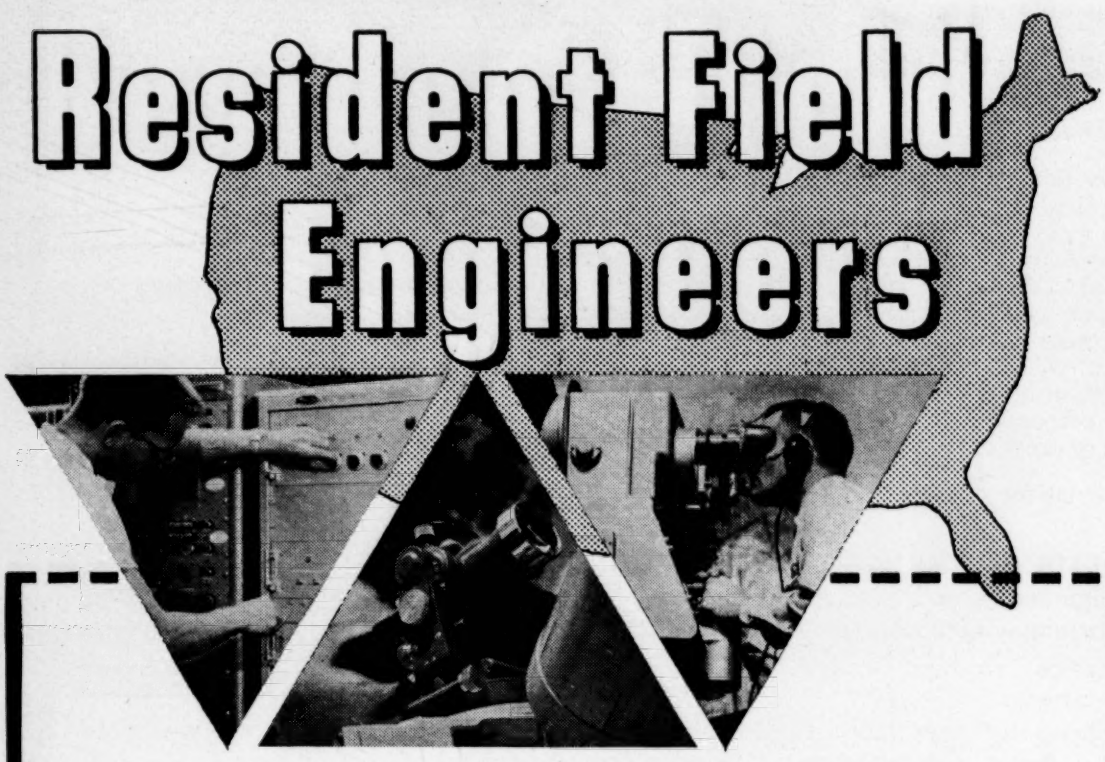

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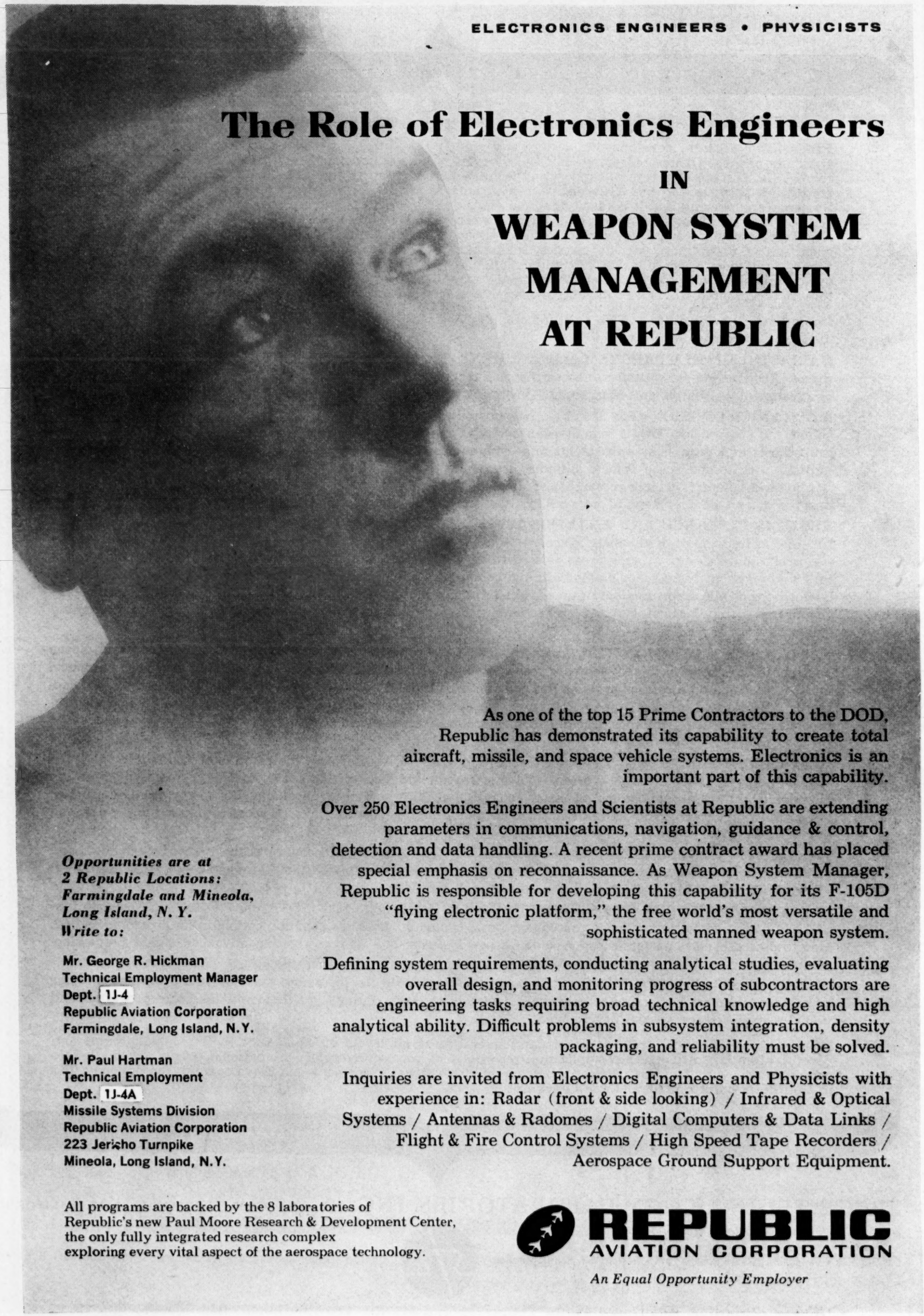

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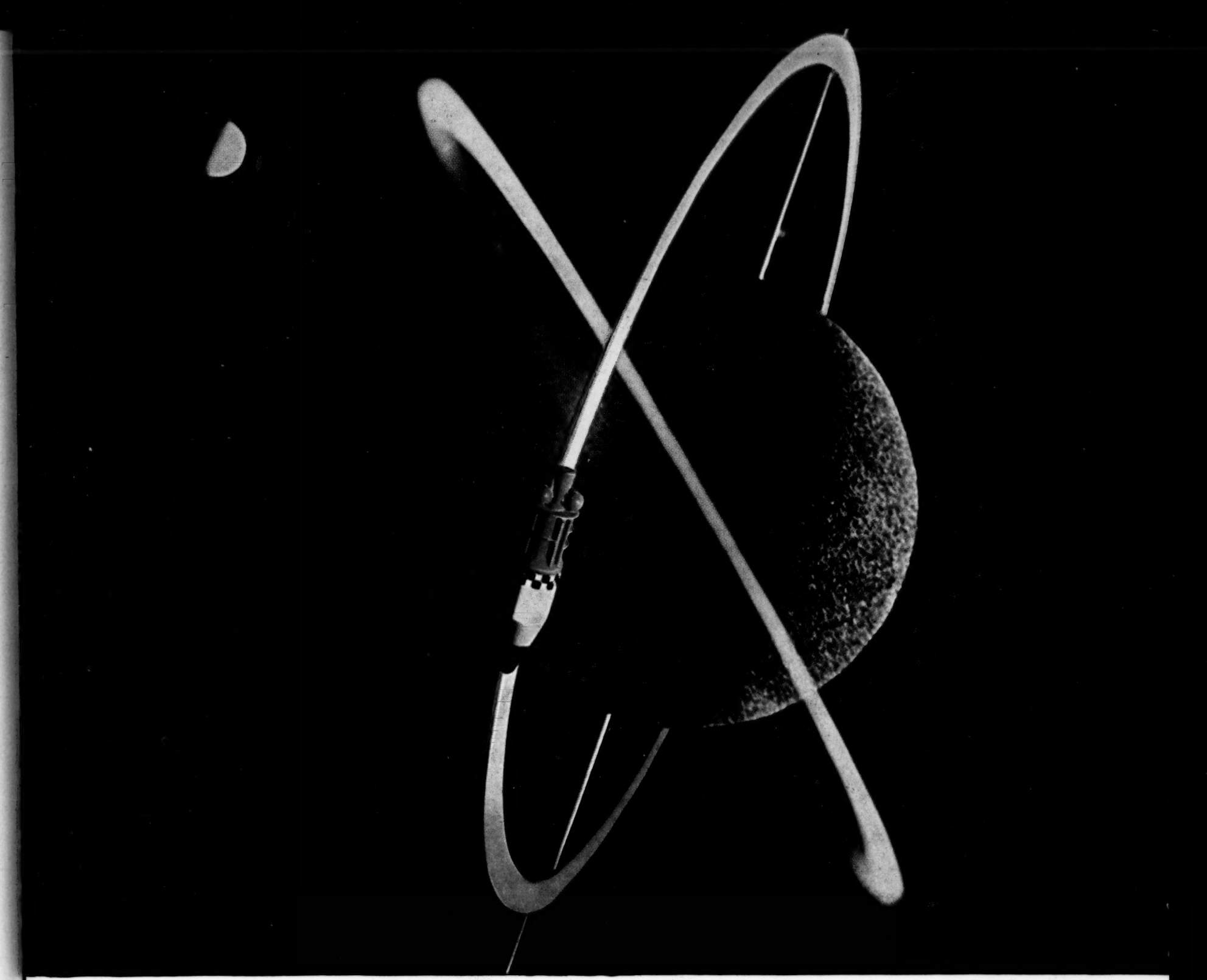

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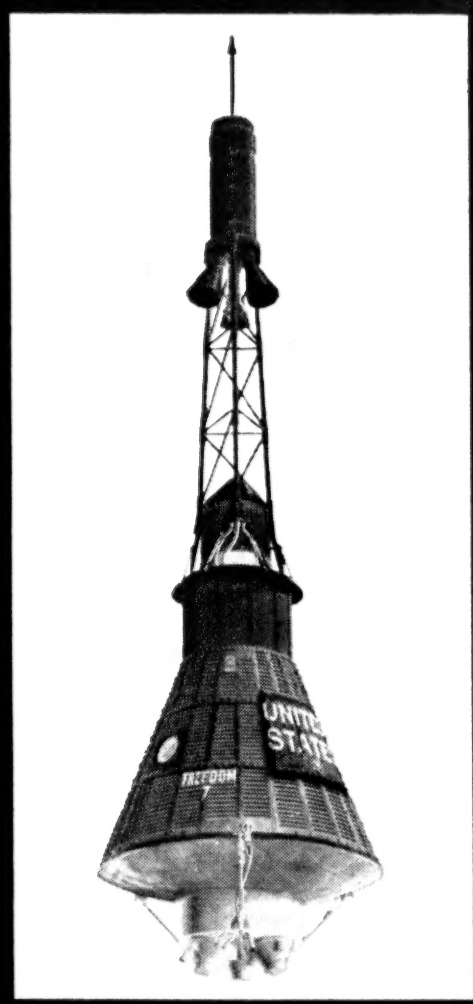

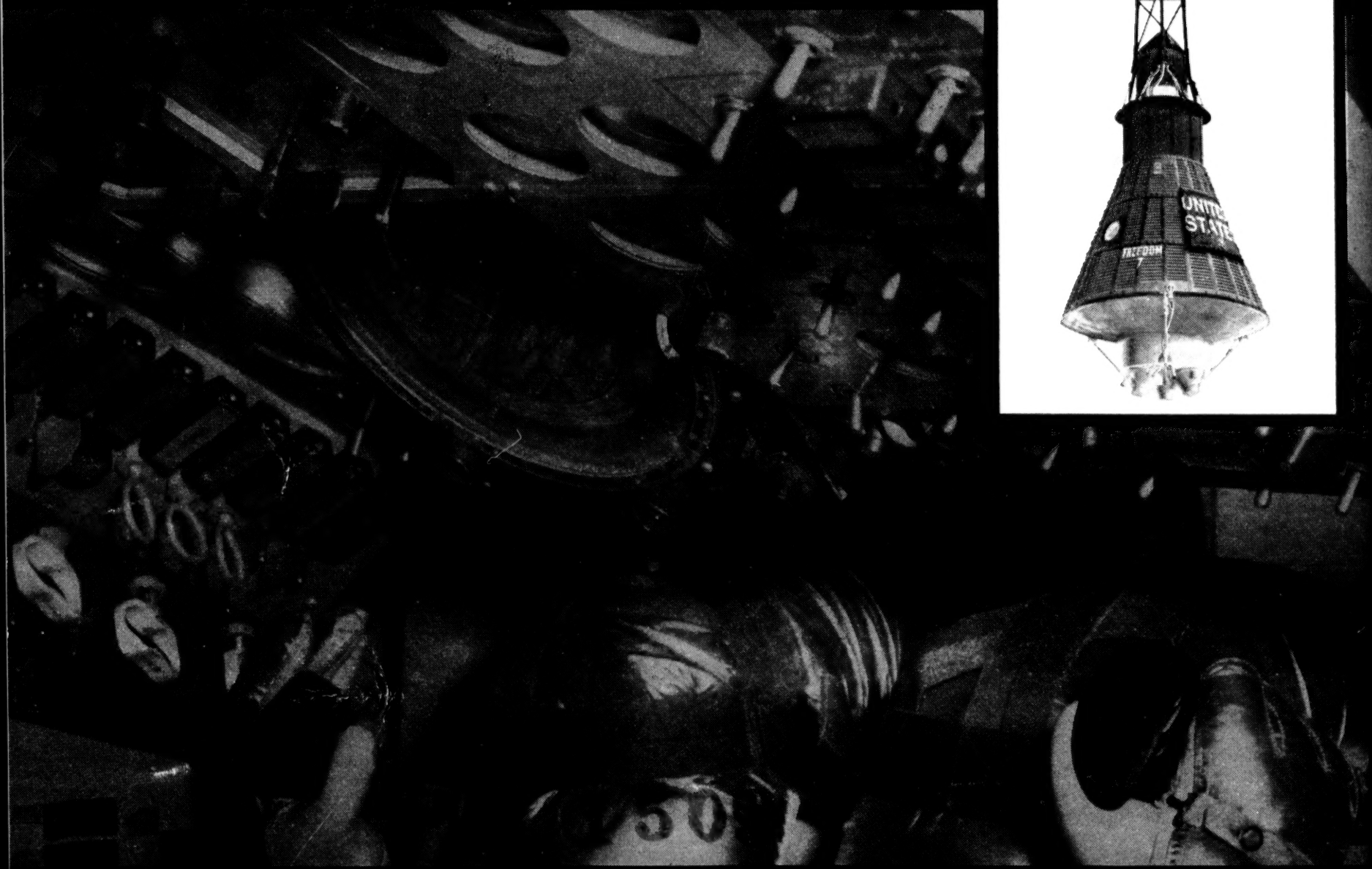

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